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TAMILNADU

CERTIFICATE FROM THE DEAN

This is to certify that the dissertation entitled **"STUDY ON MORPHOMETRY OF PROXIMAL FEMUR''** submitted by **Dr.K.GEETHANJALI,** to the Faculty of Anatomy, The Tamilnadu Dr.M.G.R. Medical University, Chennai in partial fulfilment of the requirement for the reward of M.D. Degree in Pathology is a bonafide work carried out by him during the period 2016-2018.

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DECLARATION

I, **Dr.K.GEETHANJALI,** solemnly declare that the dissertation titled ''**STUDY ON MORPHOMETRY OF PROXIMAL FEMUR**'' has been prepared by me. I also declare that this work was not submitted by me or any other, for any award, degree, diploma to any other University board either in India or abroad. This is submitted to The TamilnaduDr. M.G.R. Medical University, Chennai in partial fulfillment of the rules and regulation for the award of **M.D degree Branch-XXIII (ANATOMY)** to be held in **May-2019.**

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ASIS	-	Anterior Superior IliacSpine
AVN	-	Avascular Necrosis
BMD	-	Bone Mineral Density
BMI	-	Body Mass Index
DHS	-	Dynamic Hip Screw
HTD	-	Head Transverse Diameter
HVD	-	Head Vertical Diameter
INL	-	Neck Length Inferiorly
ITL	-	Intertrochanteric Length
NSA	-	Neck Shaft Angle
NTD	-	Neck Transverse Diameter
NVD	-	Neck Vertical Diameter
PSIS	-	Posterior Superior IliacSpine
SD	-	Standard Deviation
SHL	-	Head LengthSuperiorly
SNL	-	Neck LengthSuperiorly
THR	-	Total Hip Replacement

INTRODUCTION

INTRODUCTION

A unique characteristic of humans as compared with other mammals is erect posture. Many advantages have been gained from this erect posture, the chief among which has been the freeing of the upper limb for a great variety of uses. But erect posture has created a number of mechanical problems – in particular, weight bearing. These problems have had to be met by adaptations of the skeletal system.

The skeletal system includes the osseous tissues of the body and the connective tissues that stabilize and interconnect the individual bones. The bone is a dynamic tissue throughout the lifespan, bone adjusts to the physiologic and mechanical demands placed on it mainly by the processes of growth and remodelling. Bone serves the organism forlocomotion effectively and to maintain posture by bearing loads without deformation. This is achieved by providing rigid attachment sites for muscles. It also acts as a system of levers to amplify small movements.

As an organ, bones protect the viscera and house thehemopoietic tissue. As a tissue, bones serve as a reservoir to readily mobilize calcium. Calcium is vital for many metabolic processes including cell-motility, excitability, secretion, phagocytosis, intermediary metabolism, respiration, and also reproduction.

Among all the bones in the human skeletal system, Femur is the longest and heaviest bone that functions in transferring the body weight between the trunk and the lower limb. Femur supports the weight of the body during standing, walking and running. The structural function of the femur requires that it endures these mechanical loads by changing its shape, size and mass **(Wescott 2001).**

Femur length is roughly one-fourth to one-third of the human body length. The femur bone can be divided into three main parts which include the proximal portion (Head & Neck), the shaft and the distal portion (lower condyles). With its proximal end, it articulates with the hip bone forming the hip joint, which is a synovial ball – and – socket joint. With its distal end, it articulates with the tibia and patella forming the knee joint.

As the Femur is essential for the basic human activities, it can be assumed that these could have some effect on its shape. Especially, the actions that involve the proximal end of femur are those which act with the hip, which include the medial rotation, lateral rotation, adduction, adduction, flexion and extension and circumduction.

In the erect posture, it inclines downward, slightly backwards, medially so that the distal ends of the Femur become close together towards the knees (**Bass 1995).**

FIGURE – 1: SHOWING ACETABULUM AND UPPER END OF FEMUR FORMING THE HIP JOINT

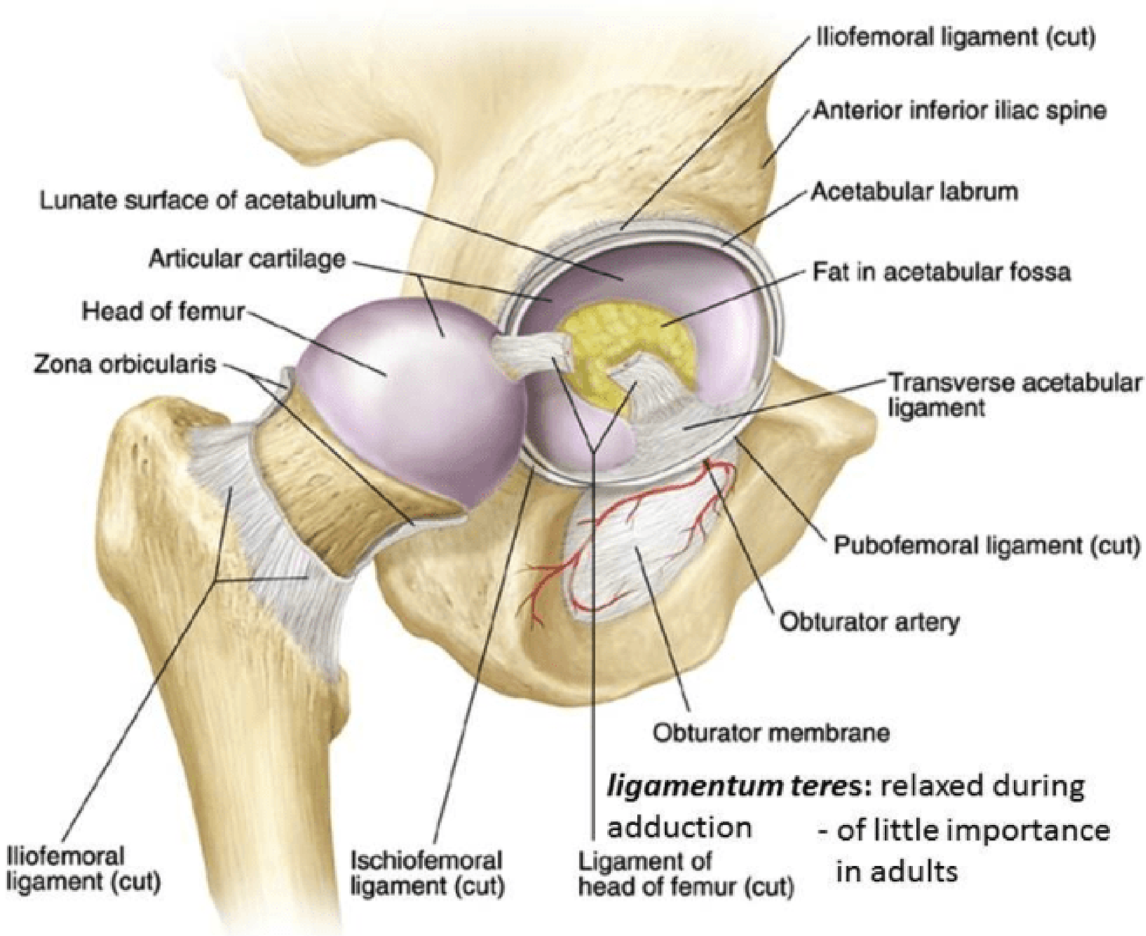
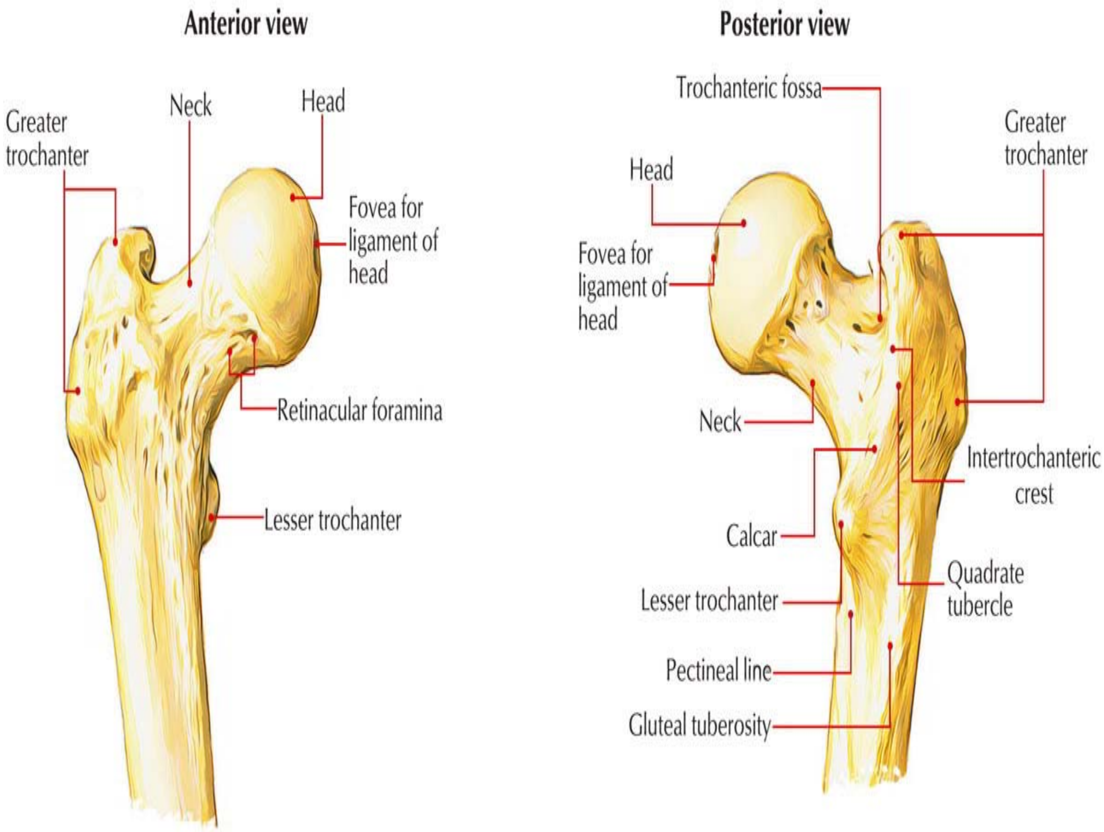


FIGURE – 2: SHOWING PROXIMAL END OF FEMUR WITH HEAD, NECK AND TROCHANTERS



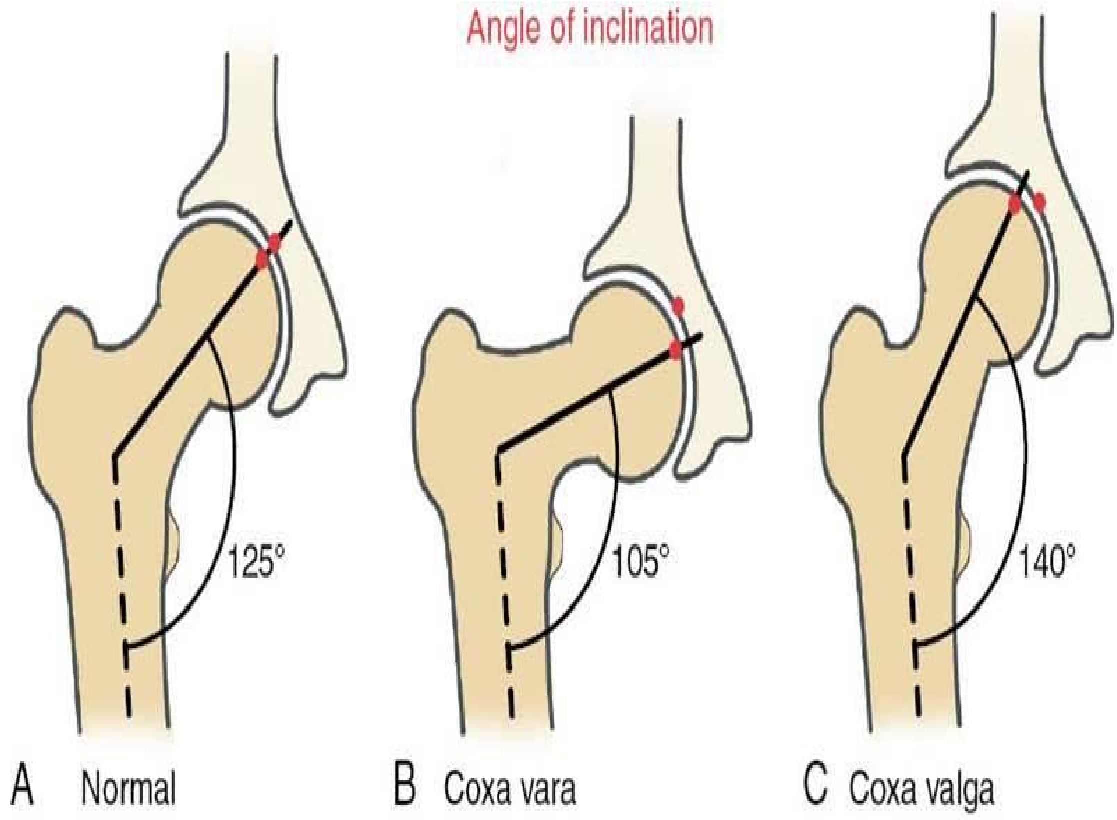
The ultimate purpose of the gradual downward and inward inclination is to bring the knee joint near the line of gravity of the body, thus producing increased balanced bipedal mobility.

There are metric differences in skeletal components among different populations and these variations are related to genetic and environmental factors also. Variations seen in human skeletal measurements also determine the racial characteristics of the populations.

Anthropometric skeletal measurements are used to show regional diversity between different populations or even within the same populations. Moreover, skeletal measurements and the shape of bones can offer a guide to clinicians for determiningthe risk factors for fractures.

Fractures are an important health burden causing disability, death, and medical costs. Mainly, hip fractures are a major problem for elderly people. The shape of the proximal femur is considered to be an important risk factor for fracture of the neck of the femur, regardless of bone mass or bone strength.

FIGURE – 3: SHOWING THE NECK SHAFT ANGLES OF FEMUR IN VARIOUS CONDITIONS



The risk of hip fracture can be predicted by factors like, Body Mass Index (BMI), bone mineral density (BMD), the direction and severity of the fall, strength of the muscle, body habitus, femoral morphometry, family history or lifestyle factors.

Few authors even reported an association of femoral geometry with hip fracture in post menopausal women especially in relation to the Femoral Neck Width.

The Femoral heads support the weight of the body entirely, suggesting that the morphometry of the proximal femur may contribute to Femoral neck strength. The proximal femur acts as a brace. The biomechanical properties of proximal Femur depend on the width and length of the Femoral neck.

Femoral morphometric parameter including Femoral neck width, Femoral head width, intertrochateric width, and Femoral neck shaft angle has been related to the mechanical strength of the upper end of Femur. These parameters are also associated with the resistance of bone to impact, the highest values being found in races with a increased incidence of hip fracture. Some of the most frequently described measurements with an increased risk of fracture include a longer hip axis length and a higher neck shaft angle.

Fractures of proximal femur involving the neck are quite frequent and internal fixation with implants is necessary for early mobilization and rehabilitation of patients. A strong correlation regarding geometric fit exists between the dimensions of implant and the fractured femur to be operated.

The morphology of proximal Femur is an essential parameter in the design and development of implant for Total Hip Replacement (THR). Hip joint replacement (hip arthroplasty) is the surgical replacement of all or part of the hip joint with an artificial material. The procedure can be either Total Hip Arthroplasty or a hemiarthroplasty.

Total Hip arthroplasty – The articular surfaces of the femur and the acetabulum are replaced.

Hemiarthroplasty-only the articular surface of the femoral head is replaced.

Most of these implants are designed and manufactured from the European and North American region which presumably are based on the morphology of their respective population.Use of these implants, adversely affects the functional end result of surgery leading to thigh pain and also inadequate implant fixation. Inappropriate implant design and size could affect the final outcome of the surgery with reported complications such as stress shielding, micromotion and loosening.

Further use of these implants from other regions may not be appropriate as the design will not take into consideration the morphology of the Indian population. The use of implants designed based on other populations posed at least two potential major issues.

First and foremost is the difference of the anthropometry of the upper end of femur between ethnics due to differences in lifestyle, physique, applied force and their distribution.

Another problem is implant-morphology mismatch that might cause difficulties during implant placement and could lead to accelerated deterioration of the implant life and thus affecting short-term and long-term outcome of the surgery.

Presently in developing countries like India, Injured femur replacements are carried out using standard sized Austin Moore femur implant selected from a range provided by the manufactures. Femur implant is available in standard sizes of diameter of the Femoral head and Femoral neck shaft angle.

When manufacturer supplied Femur implants are used for implantation, there are limitations in design of the implant. Surgeons who perform Femur replacement surgeries must depend upon the implant manufacturer to provide appropriately sized implants. These implants are manufactured for masses and not for individuals.

However, there is discrepancy in the measurement of the parameters. The neck shaft angle varies from within 125° to 132°. Undersized or overhanging femoral implants could result in altered soft-tissue tensioning and altered patella femoral stresses.

Non availability of proper shaped and sized Femur implant or improper selection of Femur implant could result in serious problems for the patients in long run. There is a paucity of literature pertaining to the effects of improperly sized implants on outcome. These observations have profound implications. They imply that a certain subset of Indian Femora do not have any implant available to them as they are very small.

Further, a shorter neck length implies that the threads of cancellous or Garden screws used to fix neck fractures may not cross the fracture site thereby failing to provide compression and thus destroying the whole purpose of the surgery. It was these observation these that prompted **Leung et al** to modify the gamma nail to suit the Asian Population.

If large amount of bone is replaced by metal a tamponade effect can occur that may cause avascularity of femoral head, consequently resulting in nonunion of neck fractures and/or AVN (Avascular Necrosis). Since Indian Femoral heads are smaller, the threads of screws often fail to cross the fracture of neck of femur especially if the fracture is sub capital and the screw placement in the inferior quadrant of head. This implies that we must have screws with shorter thread lengths.

In thin built and short individuals the neck may not have sufficient space to occupy the three 6.5mm screws recommended for fixation of neck fractures. A smaller neck shaft angle means that a Dynamic Hip Screw (DHS) inserted through the classical entry portal using angled guide will either go into the superior quadrant or pull the fracture in valgus both of which are harmful. We probably require DHS with smaller angles for restoration of normal neck shaft angle which usually changes with age of an individual.

The incidence of intraoperative complications like splintering and fractures ranges from 4 to 21%. These are due to over-sized implants available that have been manufactured basically with western parameters.

The present study is being undertaken to analyse the dimensions of proximal Femur involving the head, neck and trochanters. The standard commercially available marked prosthesis sometimes may not be the best fit to Indian patients because of wide anatomic variation which leads to complications due to mismatch like aseptic loosening, improper load distribution an discomfort.

Hence, the fracture implant designs should be specific for Indian bones. So that, more accommodating designs are needed that will enable proximal and distal filling at the femoral canal producing stable fixation may be achieved regardless of variations in bone geometry.

There is scarcity of the knowledge regarding dimensions of the head, neck and trochanters of the femur among Indian population. With the help of this study the data regarding the dimensions of the head, neck and trochanters will be obtained in Indian population which can be useful in the designing of appropriate implants to suit the Femora of Indian population, and also in reducing the complication rates due to mismatch caused by the implants and proximal Femoral dimensions.

Femur has always been the most reliable bone for Anthropometry. Femur morphometry is different between populations or geographical regions **(lgbigbi and Mishra et al).** Morphometry of the proximal femur is determined by a large number of genetic and environmental factors including age, race, sex and lifestyle. Many studies have demonstrated the clinical significance between the dimension of the Femur and the implanted prosthesis.

Presently, in developing countries like India, injured or broken Femur replacements are carried out using standard sized Austin Moore Femur implant selected from a range provided by manufacturers.

But, this is the bane of Indian orthopaedic surgeon to implant devices and prosthesis designed for Western skeletons. Not only these implants are large in size, their angles, and orientations and thread length also mismatch Indian femora. Implants are manufactured for masses and not for individuals.

Most Orthopaedic implants produced for femoral head prostheses and trochanteric fractures are designed for Western population. Moreover, they may be smaller or unsuitable in terms of size or shape for Asian or Eastern societies, leading to complications like blasts in pin placements. If these implants are designed in accordance with the proximal Femoral morphometric data of a given population, such problems can be eliminated.

Proximal Femoral morphometric data can be measured either by using a manual technique on sample cadavers directly or by using a radiographic method (**Mahaisavariya et al 2002**). In conclusion, we would like to emphasize the importance of proximal Femoral measurement which is particularly different from other populations, giving information to engineers and clinicians alike in the development of implants and practice related to the hip joint.

FIGURE – 4: SHOWING THE TRABECULAR PATTERN IN THE HEAD AND NECK OF BONE

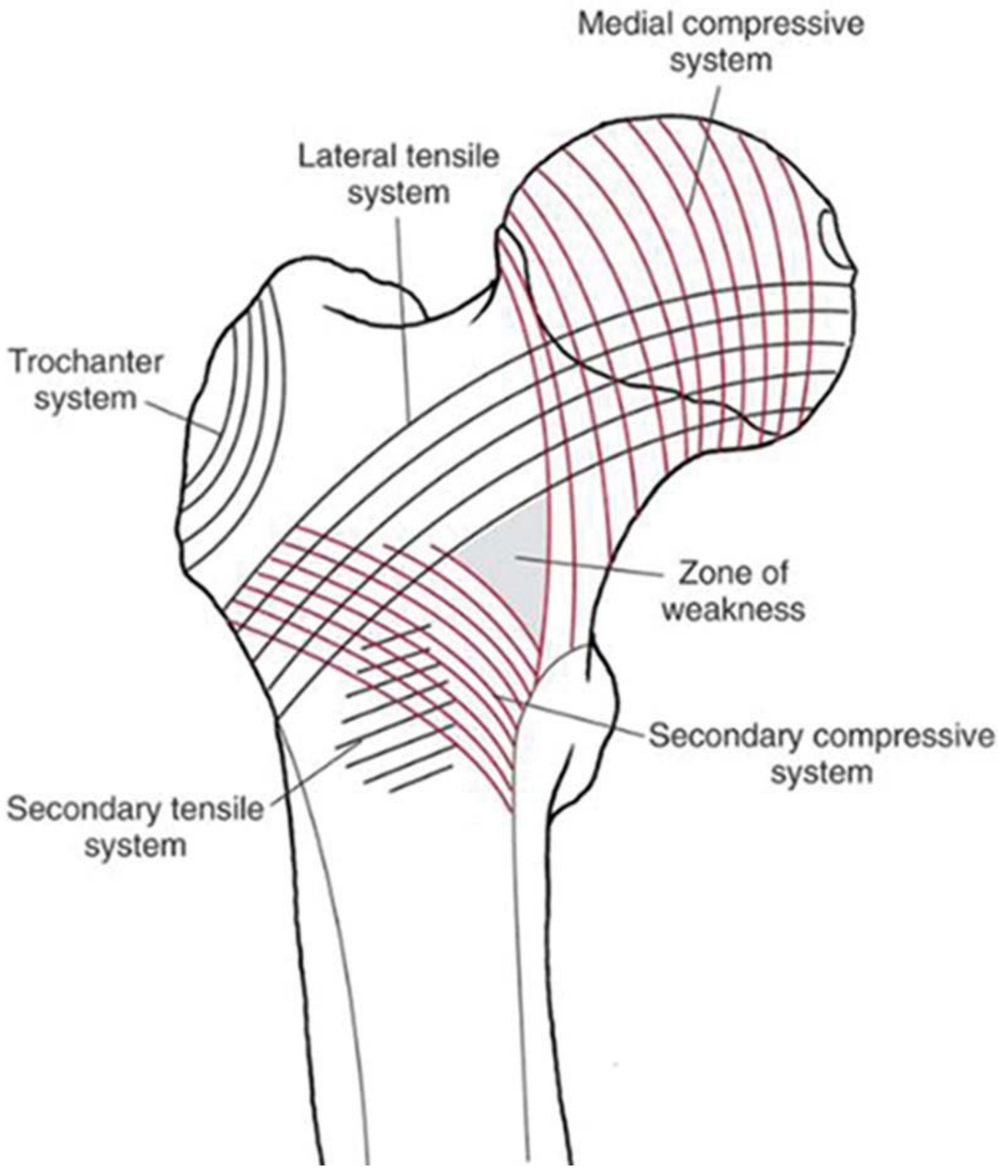
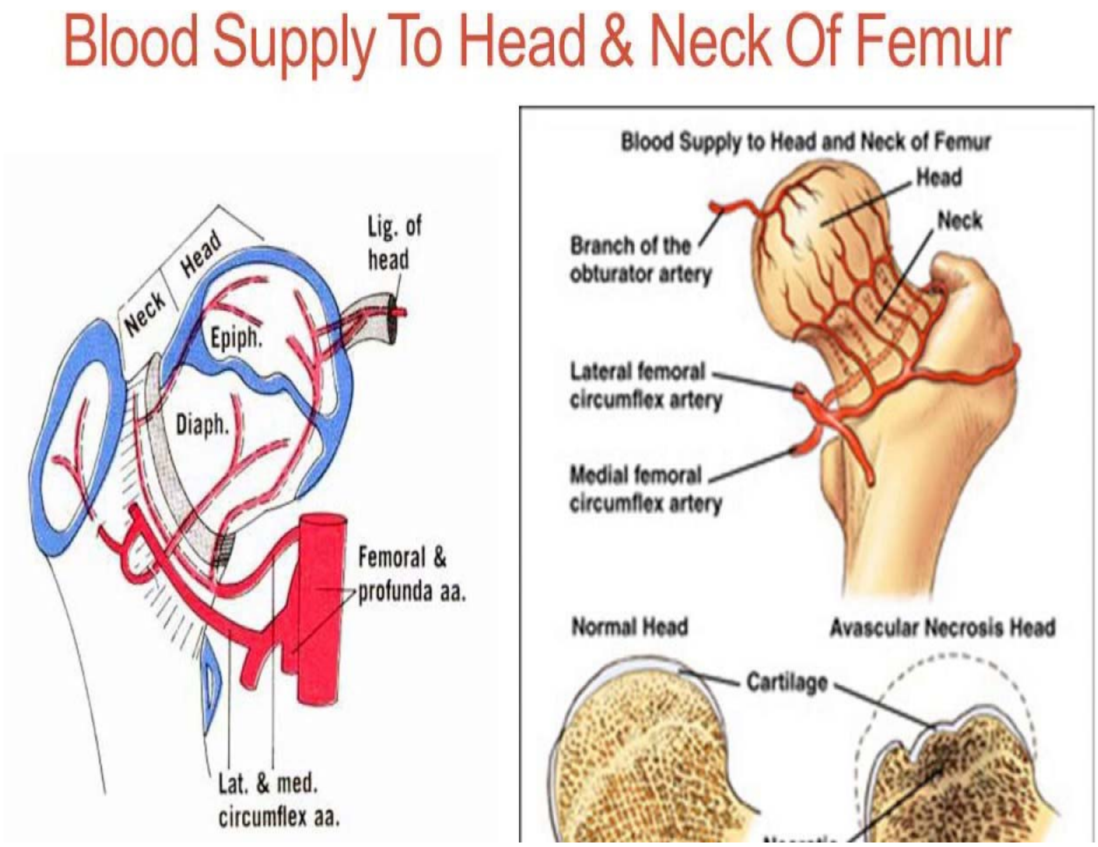


FIGURE – 5: SHOWING VASCULAR SUPPLY TO HEAD AND NECK OF FEMUR



AIMS
AND
OBJECTIVES

AIMS AND OBJECTIVES

- The osteometric study of upper end of femur with particular reference to head and neck is done by observing the Qualitative and Quantitative measurements in the femora under study.
- Qualitative features of the proximal end of femur are, the Femoral Head including Fovea Capitis, Femoral Neck, Greater and lesser trochanters, Intertrochanteric line and Intertrochanteric crest etc.
- Qualitative parameters are measured in all the femora (both right and left)
- To obtain the statistical analysis of each parameter by side wise comparison.
- To compare the values of the parameters obtained with those reported in the literature.
- To compare the values with dimensions of commonly used implants in the field of Orthopaedics.

REVIEW
OF
LITERATURE

REVIEW OF LITERATURE

Farrally MR et al (1975) the association between hip axis length and fracture risk was present even after adjustment for age, femoral neck density, height and weight. A longer hip axis length was associated not only with increased risk of feral neck fractures but also with trochanteric fractures. They said that there is no significant association between the neck width and the neck shaft angle with the risk of hip fracture.

Hoaglund FT, Low WD (1980) concluded that in adult, the axis between the neck and the shaft is about 135°. There are significant differences in morphometry of proximal femur of average Caucasian and Hong Kong Chinese population. Advanced measurement techniques have proven the lack of roundness of femoral head by stating that the meridians have longer radii than the radii of the equator. Thus, the femoral head has a subtle egg or barrel shape. There are signigicantdifferences noted in the measurements of head, neck, and proximal femoral shaft of average normal caucassian and Hong Kong Chineese population.

Atilla B et al (1995) studied in Turkish individuals and found that several femoral features were found to be different. Turkish people had a greater femoral head due to valgus position of the femoral head-neck angle, a narrower upper femoral metaphysic and also a narrower medullary canal with a longer isthmic segment. But their femoral head size and offset were same as western values. This study established that there is a diverse variation in proximal femur geometry in Turkish population compared to Western population which should be taken into account.

Issac B et al (1997) said the neck shaft angle can be measured from a proximal femoral segment (n=171) and the range is between 120 degrees to 136 degrees with a mean of 126.7 degrees and has no significant side difference. The required size of the length of the neck can be measured to manufacture exact prosthesis for the restoration of normal neck shaft angle. The angle strongly correlates with neck length, intertrochanteric axis and minimum femur length but do not correlate with the vertical diameter of head. They also stated that any estimated defective angle can be useful for forensic identification of an individual with pathological changes leading to an abnormality in gait.

Akhihikobo (1997) proposed that the fit and fill of femoral canals are essential for the success of cementless femoral stems in Total Hip Arthroplasty. They also stated that in patients with secondary osteoarthritis it is difficult to provide a good fit and fill using conventional stems

Chantarapanich N et al (1997) proposed a non-destructive method that can effectively measure the internal as well as the external 3D geometric values of femur. The data obtained can be used to develop a proper design of prosthesis that required inserting into intramedullary canal. They also stated that the 2D sagittal femoral curvature derived from standard radiographic image can be represented for 3D femoral curvature.

Fessy et al (1997) proposed that within a population there is a considerable variation in the endosteal canal anatomy of the upper end of femur. This anatomical variation affects the outcome of the total hip arthroplasy when the orthopedic surgeon uses cement less femoral shaft. They also stated that if the secondary fixation of an implant stays under the dependency of many parameters, initially one has to obtain very good primary stability by the morphological appropriateness of the bone implant. They also proposed to define the cement less indications in total hip arthroplasty, defining two radio-anatomical parameters namely, Cortico-Medullary Index and the Femoral Flare Index.

Akihiko Bo et al (1997) stated that the fit and fill of the femoral canal are essential for the success of cement less femoral stems in total hip arthroplasty. It is difficult for conventional stems to provide a better fit and fill for the patients with secondary osteoarthritis.

Hussmann (1997) proposed that in the field of uncementedarthroplasties, secondary biological fixation of femoral implants is directly dependent on the quality of the primary stability. Metaphyseal stability and an appropriate fit between the implant and the proximal femur improve initial stabilization and optimize the transmission forces to the femur. So precise knowledge of the three dimensional femoral shape is needed to the design and selection of implants.

Auley J P et al (1998) pointed that total hip arthroplasty performed without cement can be successful in older patients and the study also provided a reference for comparison with the outcome of total hip arthroplasty performed using cement and those of hybrid total hip arthroplasty, in which an acetabular component is fixed without cement and a femoral component is fixed with cement in older patients.

Duthie et al (1998) did a osteometric study using cadaveric bones and explained a significant increase in measures of length and width of femoral neck in male and female, suggesting a evolutionary change in the morphometric pattern of Scottish population compared to earlier skeletons available

Nwoha P U et al (1999) found that the transverse and vertical diameters of the head of the femur in 256 adult Nigerians were measured on the X-ray films of the hips of these subjects. There was no significant difference between the diameters of the left and right femoral heads but the diameters in the males were significantly greater than in the females. The vertical diameter and transverse diameter reported by Singh et al in Calabar men, and transverse diameter for women were significantly larger than those reported by Nwoha P U et al suggesting the existence of regional variation of the head of the femur in Nigerians. The vertical diameter and transverse diameter reported for Nigerians were greater than those reported for Caucassians, Indians and Chineese, supporting racial and geographical variation in the head of the femur.

P J Rubin (1999) stated that as there is a great variation in morphometry of femur in normal population and that is the reason for difficulty in precise bone-implant and stated that there are only few detailed studies on geometry of femur. A new approach to three dimensional imaging arose from the use of CT Scans for the design of custom-made prostheses and to compare the internal and external geometry of proximal femur as obtained from X-Rays or CT Scans with actual measurements of anatomical specimens used. The reconstructed femur generated with these measurements was used as the reference. They concluded that CT scan is an accurate technique in experimental conditions and its accuracy remains sufficient in the clinical situation when care is taken to limit technical precisions. Radiological accuracy could be improved in the future by a computerized correction of radiological femoral dimensions through the availability of banks of anatomical or CT scan generated three dimensional data.

Mall G et al (2000) concluded that the identification of sex from bones or bone fragments considerably contributes to identifying unknown bodies or skeletal remains. Due to temporal change and regional differences anthropometric standards have to be constantly updated. Measurements of femoral dimensions in German population that analyses dimorphism by discriminate analysis have also been described.

Igbigbi (2000) proposed that the vertical and transverse diameters of femoral heads of males were significantly more than the corresponding diameters of femoral head of females. This study also provided standard data for black Malawian population with the recommendation that same standard values can also be established for other African countries.

Asala S.A et al (2001) proposed that the diameter of the headof the femur and the identification and differentiating points that are derived from them are sexually dimorphic in South Africa and Black populations.

Nobel P C et al (2001) proposed that the shape of femoral canal is much more variable than most contemporary designs of femoral components would suggest. Considering this variability, line-to-line or surface-to-surface contact is not required between cement less implants and much of the endosteal surface. It is apparent that changes in implant design are still needed if the normal biomechanics of the hip joint are to be restored. The Neck Shaft Angle in their study was found to be 125.4 degrees. And also accommodating designs of femoral components are required that will enable proximal and distal fitting at the femoral canal so that stable fixation could be achieved regardless of variation in bone geometry.

Taner Z (2002) studied the morphometry of the femur of contemporary mid- Anatolian Population who died during the twentieth century. He measured mean values of the lengths of right and left femur and found them to be the same. Femoral anthropometry from the two different time periods revealed a great amount of variations that are most probably the results of variable factors such as nature of work, mode of life, continuous modifications that may affect the characteristics of man as well as the effects of civilization on the composition of human body in both positive and negative ways. He stated that anthropometric measurements could show differences between various populations from different ages and these may be considered to be constantly researched.

Pawlikowski M et al (2003) proposed that the design of hip joint prosthesis is a highly complex process which requires close co-operation between engineers and orthopaedic surgeons. To design prosthesis of higher durability one has to take into consideration natural processes occurring in bone. In this study the visco-elastic properties of bone and bone remodeling were taken into consideration, which is a novel approach in prosthesis design.

Siwach RC and DahiyaS (2003) stated that the use of implants designed for western population should be restricted and in future implant design must be customized to suit the Indian population. With the use of implants designed for western population the incidence of intra-operative complications like fractures and splintering ranges from 4% to 21%. They also stated that the over sized implants which are available have been manufactured on the basis of western parameters. A strong association has been established between the incidence of thigh pain and inadequate fit and fixation of implant. The mean neck width obtained in the study is 31.8mm.

Calis et al (2004) reported a strong association between femoral geometry with the fractures of hip in postmenopausal females, particularly in relation to the width of the neck.

AkhtariAfroze (2005) worked o variations of femoral head diameters in relation gender in people of Bangladesh and showed that the diameters of femoral head as well as the identification points derived from them are useful in sex determination. They also stated that their study is of value not only to orthopaedicians but also to forensic experts.

MohdYusof Baharuddin et al (2006) studied the differences between Asian and Western femoral morphology and ppointed out that this difference could be used as a guide to improve the design of commercially available femoral stems particularly for Asian populations. By analyzing the peculiar characteristics of Asian femur, better designs with optimal fit and fill can be manufactured, which will prolong the lifetime of the implant and reduce other complications such as micromotion, loosening, stress shielding and fractures. The mean femoral head vertical diameter obtained in their study is 43.67 mm. the conclusion of this methodology is optimized load transfer, minimum stem micro motion, increase in initial stability and extended durability.

Saikia K C et al (2008) stated that the knowledge of the anatomical parameters of the bony components of the hip joint is very essential for understanding of the etiopathogenesis of diseases like primary osteoarthritis of the hip joint. Their study compared various parameters among the Mangoloids and Caucasoids and found that the values on the left side were higher than on the right side in parameters like Neck shaft angle. The Neck shaft Angle was found to be 139 degree on left side and 140.7 degree on right side.

Toogood P.A (2008) gave a complete description of morphology of proximal femur. According to this framework, determined normal population Means, Standard deviations and Ranges established differences among subpopulations and showed correlations among various measurements. Two parameters of Neck Shaft relationship were analyzed, Neck version and Angle of Inclination. Gender differences and differences between those younger and older than 50 years were observed. And also correlations between the concavities of neck and neck shaft relationship were obtained

CK Chie (2009) stated that both the femoral neck and femoral neck shaft angles were not factors influencing the placement of femoral neck lag screws and anti-rotation pin in the nailing of proximal femur. But case to case evaluation is required to exclude cases with extremely narrow femoral neck width. In these cases implant with a single femoral screw nail can be used.

Mishra A K et al (2009) stated that implants that are designed considering the anthropometric and biochemical data will help in designing patient specific implants which minimize the complications.

AasisUnnanuntana (2010) proposed that knowledge on the morphology of proximal femur will assist the surgeon in restoring the geometry of the proximal femur during total hip arthroplasty. He found statistically significant difference between males and females in Neck Shaft Angle, Neck Inclination, and absolute horizontal and vertical offset. No correlation was found between the two offsets.

Bokariya P et al (2010) said that anthropometric findings can be helpful in intramedullary nailing of all long bones particularly in weight bearing femur.

Eduardo Branco de Sousa et al (2010) explained that racial differences are present in the femoral neck "off-set" and stressed on the significance of this measure in the production of hip joint prosthesis to maintain the lever arm of the hip abductor.

MuraliManju B Vet al (2011) proposed that ill fitting implant offemur can produce pain in the anterior aspect of thigh and other clinicalproblems. They measured the morphometry of the head and neck of femur for Indian population. As the implantation surgery is based on the anatomical measurements, the study was done with reference to clinical application, so that the data obtained are useful not only for the Orthopaedicians, but also to the Anthropologists. TheMeanNeck Transverse Diameter (n=50) is observed to be 23.9mmin their study.

Horacio Osorio et al (2012) explained that calculating femoral length with te dimensions of upper end of femur is of great value for application in physical anthropology, forensic identification of an individual and medical jurisprudence. They obtained average values of the morphometry of proximal femur in the Chilean people. They found no significant difference between right and left femurs. Their data may contribute in analyzing the causal factors for hip fractures in Chile and may also determine predictive values in the study of at-risk group.

This study (n=81) found the mean neck length of the femur as 35.9mm and neck shaft angle as 124.17degrees.

Clark JM et al (2012) was of the opinion that the normal shape of proximal femur varies and it appears to reflect adaptation to physiological variations along the line of action of muscle forces in the absence of intrinsic bone disease.

Rawal et al (2012) said that the standard commercially available prostheses sometimes may not be the best fit to Indian patients because of the large anatomical variations. Orthopedic surgeons always stress the need for a proper implant- patient match in hip joint replacements especially for cement less femoral stem. The complications of mismatch are aseptic loosening, improper load distribution and discomfort. A difference of 16.8 % was found in the femoral head offset between Indian and Swiss populations, which can significantly affect soft tissue tension and range of motions. This study concluded a need for redesign of femoral stems. The obtained anthropometric femoral dimensions can be used to design and develop hip joint prosthesis in India and can also be used in forensic anthropometric studies.

David S. Casper et al (2012) proposed that the ability of uncementedfemoral stems to osseointegrate properly depends largely on their fit in the proximal femur after evaluating the morphometry of the proximal femur based on age and sex. He also noted that significant difference exists between the male and female proximal femoral geometry. This mostly attributed to the loss of cortical bone, demonstrating the need of considering age and sex while selecting a proper prosthesis.

Jeremy Gebhart et al (2012) stated that the contralateral femur is frequently used for preoperative templating for Total Hip Arthroplasty or Hemiarthroplasty when the proximal femur is deformed by degenerative changes or fracture. All femoral measurements had an absolute difference less than 2 mm and difference in asymmetry was less than 2 % for the femoral head, less than 4 % for the femoral neck and less than 3.5 % for the femoral shaft. This data support assumptions of substantial symmetry of the proximal femur and stated that asymmetry is not affected by demographics or the size of proximal femur. Asymmetry does not occur in isolated segments of the femur.

Amir A Jamali et al (2013) said that the morphology in femoroacetabular impingement has been used in the development of osteoarthritis. The alpha angle and femoral head/neck offset are used to determine femoral head asphericity. The study aimed at finding normal values for the alpha angle in adolescents. And also defines the location along the neck with the highest alpha angle and determine normal femoral head and neck radii and femoral head/neck offset. This will be helpful for distinction between normal and abnormal morphologic features of the femoral head.

QingshanGuo et al (2013) aimed at comparing the clinical effectiveness of the percutaneous compression plate and proximal femoral nail anti-rotation in the treatment on intertrochanteric fractures in older patients. Also evaluation variables like operation time, intra and perioperative blood losses were used to compare these two implants. They found that both of them appear to have similar clinical effects in treating elderly patients with intertrochanteric fractures.

EbCaetano (2016) stressed on importance of femoral morphometry of Brazillian people and also emphasized on importance of geometry of proximal segment of the femur in clinical practice particularly in relation to risk of bone fractures.

FIGURE – 6: SHOWING THE PROXIMAL END AND SHAFT OF THE FEMORA UNDER STUDY

MATERIAL AND METHODS

MATERIALS AND METHODS

The materials for the present study comprised of 100 (50 right and 50 left) adult dry femora from Institute of Anatomy, Madurai Medical College for osteometric study.

INCLUSION CRITERIA

Adult human dry femur bones of both sexes in the Institute of Anatomy, Madurai Medical College.

EXCLUSION CRITERIA

Bones with visible osseous pathologies like tumors, deformities, fractures, Trauma.

INSTRUMENTS USED

Verniercalipers and Goniometers are used for taking measurements.

PARAMETERS

The following parameters are measured with respect to proximal end of femur, using Vernier Callipers and Goniometer.

- Head Vertical Diameter
- Head Transverse Diameter
- Neck Vertical Diameter
- Neck Transverse Diameter

- Head Length Superiorly
- Head Length Inferiorly
- Neck Length Superiorly
- Neck Length Inferiorly
- Intertrochanteric Length
- Neck Shaft Angle

Head Vertical Diameter

It is measured between the highest and deepest points of equator of femoral head. It is measured by holding in a way that fovea centralis is seen and avoiding the margins of articular surface of head, calipers were rotated side to side until maximum diameter was obtained. It is measured as the maximum diameter of femoral head in equatorial plane by using VernierCalipers in millimetres.

Head Transverse Diameter

It is measured between the most laterally projected points on equatorial plane taken at right angles to the Vertical Head Diameter, avoiding the margins of articular surface of head. Measurement was taken by using Verniercalipers in millimetres.

Head Length Superiorly

It is measured as the distance between the base of the head to the margin of fovea capitis in the center of the femoral head. Measurements were taken with the help of Verniercalipers on the superior aspect.

Head Length Superiorly

It is measured as the distance between the base of the head to the margin of fovea capitis in the center of the femoral head. Measurements were taken with the help of Verniercalipers on the superior aspect.

Head Length Inferiorly

It is measured as the distance between the base of the head to the margin of fovea capitis in the center of the femoral head. Measurements were taken with the help of Verniercalipers on the inferior aspect.

Neck Vertical Diameter

It is measured as the minimum diameter of the neck of femur at the supero-inferior direction. It is also called as the Femoral Neck Width. Neck Vertical Diameter was measured at the narrowest part of neck between superior and inferior surfaces of the neck as the shortest distance within the neck perpendicular to the femoral neck axis. Measurement was taken with the help of Verniercaliper in millimetres.

Neck Transverse Diameter

It is the minimum diameter of the neck at the antero-posterior direction. Neck transverse diameter was measured at the narrowest part of the neck of the femur between the anterior and posterior surfaces of the neck. It was measured with the help of Verniercalipers in millimetres.

Neck Length Superiorly

It is measured along the long axis of the neck of femur as the distance between the base of the head and mid-point of intertrochanteric crest over the posterior aspect of the femoral neck. Measurement was taken with the help of Verniercalipers in millimetres.

Neck Length Inferiorly

It is measured along the long axis of neck of the femur as the distance between the base of head and mid-point on intertrochanteric line on the anterior aspect of the femur. Measurement was taken with the help of Verniercalipers in millimetres.

Neck Shaft Angle

It was measured on the anterior surface of the femur as the Obtuse angle between the long axis of neck and the long axis of the proximal part of the shaft of the femur. Neck axis is drawn in the center of the neck of the femur by joining two points equidistant from the superior and inferior surface of the femoral neck and parallel to it. The femoral shaft axis is defined by the line drawn through the centre of the medullary canal along axis of the femur. It is measured with the help of Goniometer in degrees.

Intertrochanteric Length

It is measured at a point immediately above the lesser trochanter to the most lateral aspect of greater trochanter. It is measured with the help of Verniercalipers in millimetres.

For all the 100 femora both the quantitative as well as the qualitative assessment was done. The quantitative data is subjected for the statistical analysis (Descriptive) and the results are presented.

OBSERVATIONS

OBSERVATIONS

The present study was undertaken on 100 dry adult femurs. The study was done both qualitatively and quantitatively. Osteometric analysis was done on the proximal end of femur.

QUALITATIVE FEATURES

The femora were studied qualitatively under the following features.

FEMORAL HEAD

In the present study, femoral head appears normal in shape (more than half a sphere).

FOVEA CENRALIS

Fovea centralis is found to be normal in position in all the specimens (just above the center of head) and shape is rounded in all specimens except in 7 specimens, where it is found to be oval in shape.

FEMORAL NECK

In the present study, the femoral neck with numerous vascular foramina on its anterior surface is observed.

GREATER TROCHANTER

It is observed as the quadrilateral bony prominence over the lateral aspect of the head at the junction of the neck and the shaft in all the 100 bones.

LESSER TROCHANTER

It is observed as the conical projection over the posteromedial aspect of the femoral head at its junction with the neck in all the 100 bones, except in 2 in which the shape to of the lesser trochanter appears to be rounded.

INTERTROCHANTERIC LINE

In the present study, it is seen as the prominent ridge over the anterior aspect at the femoral neck with the shaft in all the 100 bones.

INTERTROCHANTERIC CREST

In the present study, it is observed as smooth ridge over the posterior surface at the junction of the femoral neck with the shaft.

GLUTEAL TUBEROSITY

It is observed over the posterior aspect of the femur in all the 100 bones except in 3 specimens, in which it is depressed and flat.

QUANTITATIVE MEASUREMENTS

Various measurements of the proximal end of the femur are noted with the help of Verniercalipers and Goniometer, in 100 dry femora obtained from Institute Of Anatomy, Madurai Medical College belonging to both sides (50 right and 50 left) and side to side comparison was done.

STATISTICAL ANALYSIS

The present study is a cross – sectional observational study.

All the parameters of femora belonging to both right and left sides were tabulated; mean and standard deviation were calculated.

The Student t – test was applied and the side wise comparison is done by a two-tailed student t-test.

A level of significance of 5 percent ($P<0.05$) was used for all analysis.

The parameters under study are:

- Head Vertical Diameter
- Head Transverse Diameter
- Neck Vertical Diameter
- Neck Transverse Diameter
- Head Length Superiorly
- Head Length Inferiorly
- Neck Length Superiorly
- Neck Length Inferiorly
- Intertrochanteric Length
- Neck Shaft Angle

FIGURE -7: SHOWING MEASUREMENT OF FEMORAL HEAD VERTICAL DIAMETER USING VERNIER CALIPERS

Head vertical diameter is measured between the highest and deepest points of equator of femoral head. It is measured as the maximum diameter of femoral head in equatorial plane by using VernierCalipers. The two tailed student t-test is applied and the mean, standard deviation, Range, p-value, t-value are obtained. By applying the p and t value statistical significance was analysed.

Table – 1

Comparison of Mean and SD of Head Vertical Diameter (HVD)

HVD in mm	Sample Size	Mean	SD	p-value	Inference
Right	50	41.83	3.75	>0.05	Not Significant
Left	50	41.97	4.11		

No significant side difference is noted in head vertical diameter on comparing both sides.

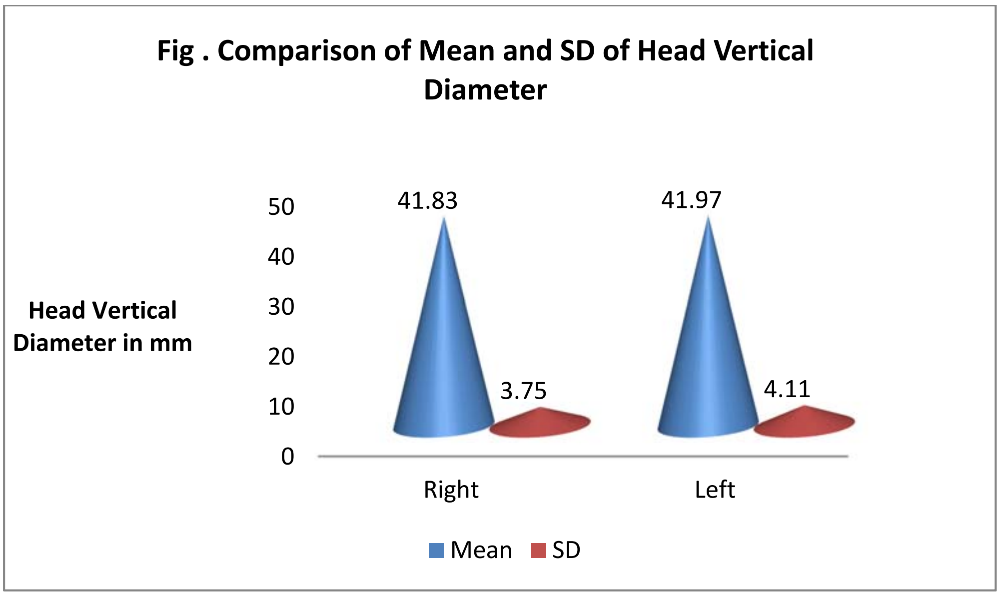


FIGURE -8: SHOWING MEASUREMENT OF FEMORAL HEAD TRANSVERSE DIAMETER USING VERNIER CALIPERS

Head transverse diameter is measured along most latterly projected points on equatorial plane. It is measured with VernierCalipers at right angle to vertical diameter of femoral head. The two tailed student t-test is applied and the mean, standard deviation, Range, p-value, t-value are obtained. By applying the p and t value statistical significance was analysed.

Table – 2

Comparison of Mean and SD of Head Transverse Diameter (HTD)

HTD in mm	Sample Size	Mean	SD	p-value	Inference
Right	50	43.15	3.55	>0.05	Not Significant
Left	50	43.41	3.77		

No significant side difference is noted in head transverse diameter on comparing both sides.

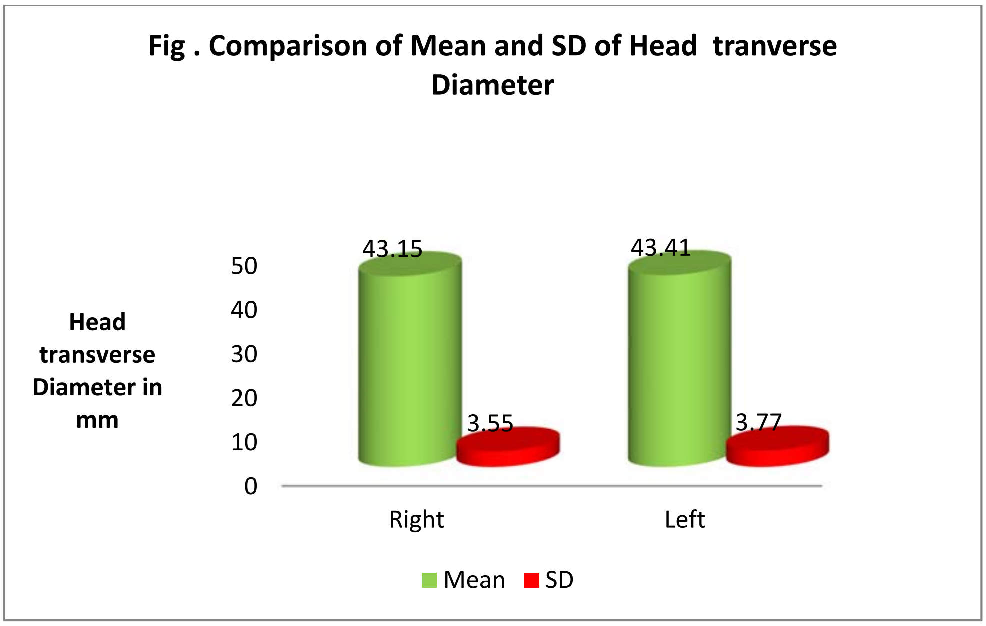


FIGURE -9: SHOWING MEASUREMENT OF FEMORAL NECK VERTICAL DIAMETER USING VERNIER CALIPERS

Neck Vertical diameter is measured as the minimum diameter in the supero-inferior direction of the neck of femur. The two tailed student t-test is applied and the mean, standard deviation, Range, p-value, t-value are obtained. By applying the p and t value statistical significance was analysed.

Table – 3

Comparison of Mean and SD of Neck Vertical Diameter (NVD)

NVD in mm	Sample Size	Mean	SD	p-value	Inference
Right	50	31.68	3.43	>0.05	Not Significant
Left	50	32.66	4		

No significant side difference is noted in Neck Vertical diameter on comparing both sides

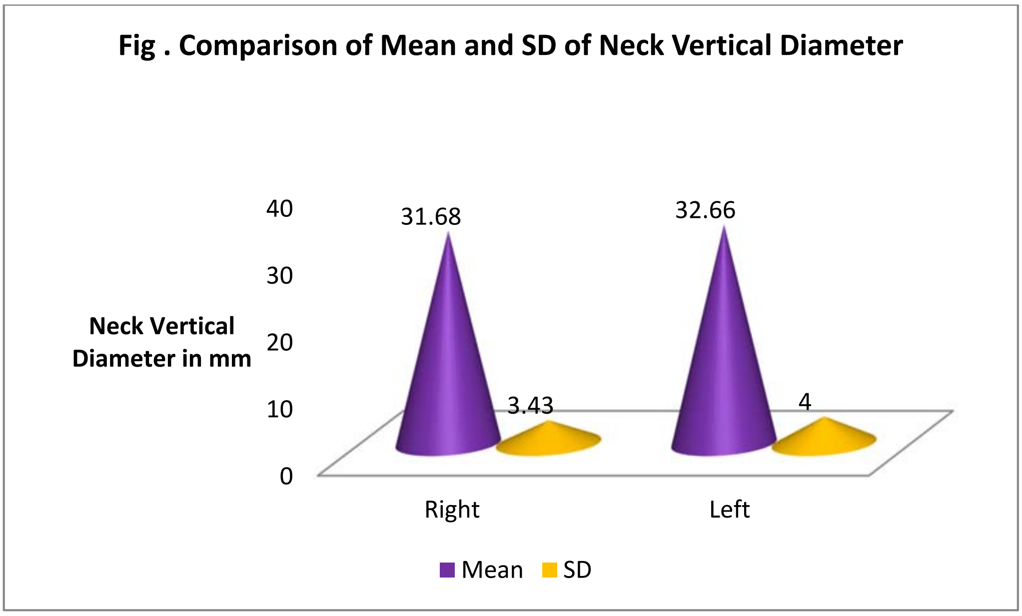


FIGURE -10: SHOWING MEASUREMENT OF FEMORAL NECK TRANSVERSE DIAMETER USING VERNIER CALIPERS

Neck Transverse diameter is measured as the minimum diameter of the neck of the femur in antero-posterior direction. The two tailed student t-test is applied and the mean, standard deviation, Range, p-value, t-value are obtained. By applying the p and t value statistical significance was analysed.

Table – 4

Comparison of Mean and SD of Neck Transverse Diameter (NTD)

NTD in mm	Sample Size	Mean	SD	p-value	Inference
Right	50	24.24	2.46	<0.05	Highly Significant
Left	50	25.83	2.95		

Significant statistical difference in mean and standard deviation is observed in relation to neck transverse diameter on comparison.

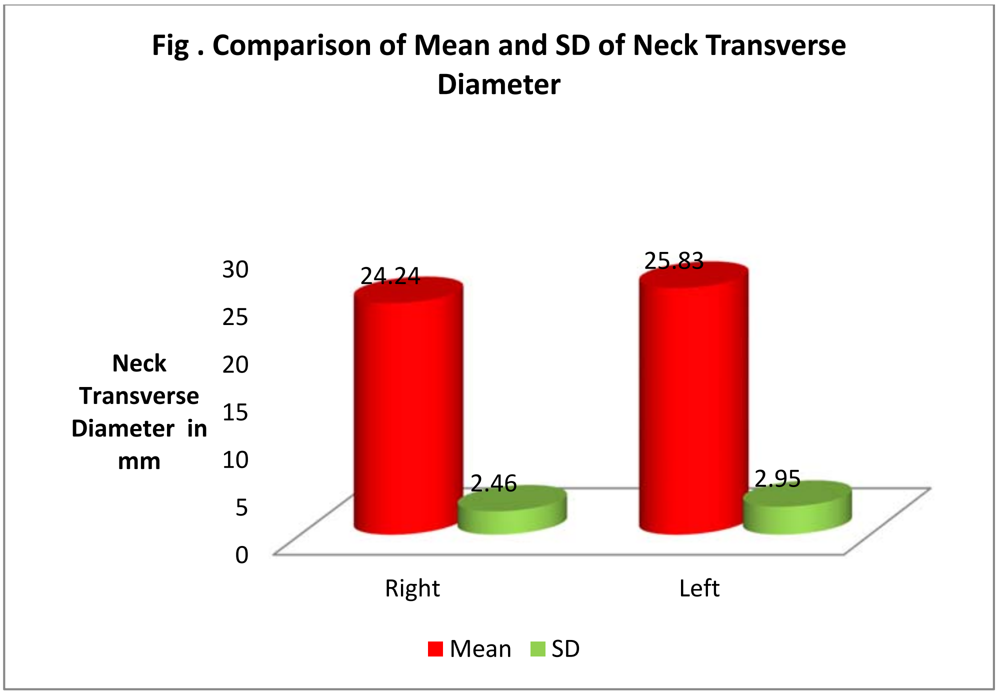


FIGURE -11: SHOWING MEASUREMENT OF FEMORAL HEAD LENGTH SUPERIORLY USING VERNIER CALIPERS

Head Length Superiorly: It is obtained by measuring the distance between the base of the head and the margins of foveacapitis located at the center of the head region. The two tailed student t-test is applied and the mean, standard deviation, Range, p-value, t-value are obtained. By applying the p and t value statistical significance was analysed.

Table – 5

Comparison of Mean and SD of Head Length Superiorly (HLS)

H LS in mm	Sample Size	Mean	SD	p-value	Inference
Right	50	31.38	3.47	>0.05	Not Significant
Left	50	32.18	3.49		

No significant side difference is noted in Head Length Superiorly on comparing both sides.

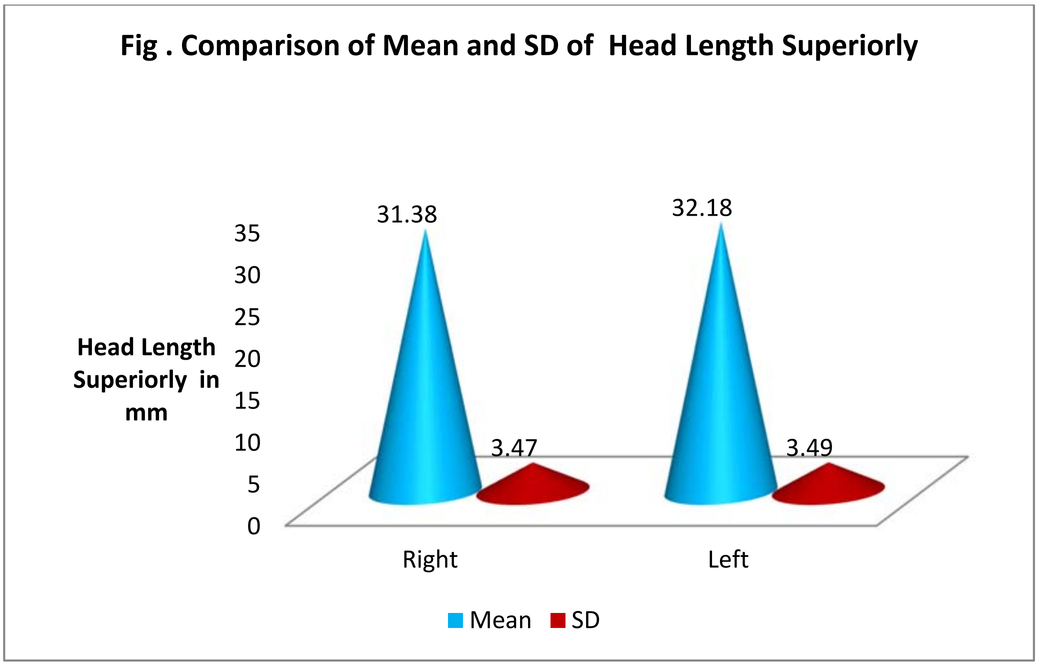


FIGURE -12: SHOWING MEASUREMENT OF FEMORAL HEAD LENGTH INFERIORLY USING VERNIER CALIPERS

Head Length Inferiorly is obtained as a distance measured between the bases of femur head to the margins of the foveacapitis located in the center of femoral head. The two tailed student t-test is applied and the mean, standard deviation, Range, p-value, t-value are obtained. By applying the p and t value statistical significance was analysed.

Table – 6

Comparison of Mean and SD of Head Length Inferiorly (HLI)

HLI in mm	Sample Size	Mean	SD	p-value	Inference
Right	50	23.13	2.98	>0.05	Not Significant
Left	50	22.47	2.79		

No significant side difference is noted in Head Length Inferiorly on comparing both sides.

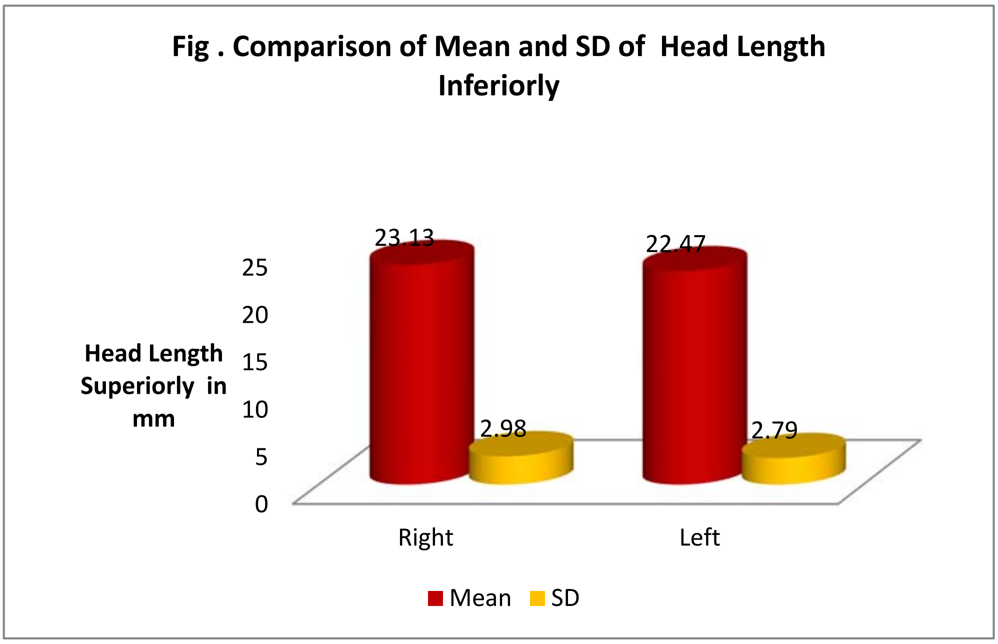


FIGURE -13: SHOWING MEASUREMENT OF FEMORAL NECK LENGTH SUPERIORLY USING VERNIER CALIPERS

Neck Length Superiorly is measured between bases of the head and mid-points of intertrochanteric line using verniercalipers. The two tailed student t-test is applied and the mean, standard deviation, Range, p-value, t-value are obtained. By applying the p and t value statistical significance was analysed.

Table – 7

Comparison of Mean and SD of Neck Length Superiorly (NLS)

NLS in mm	Sample Size	Mean	SD	p-value	Inference
Right	50	22.91	2.59	>0.05	Not Significant
Left	50	23.66	3.62		

No significant side difference is noted in Neck Length Superiorly on comparing both sides.

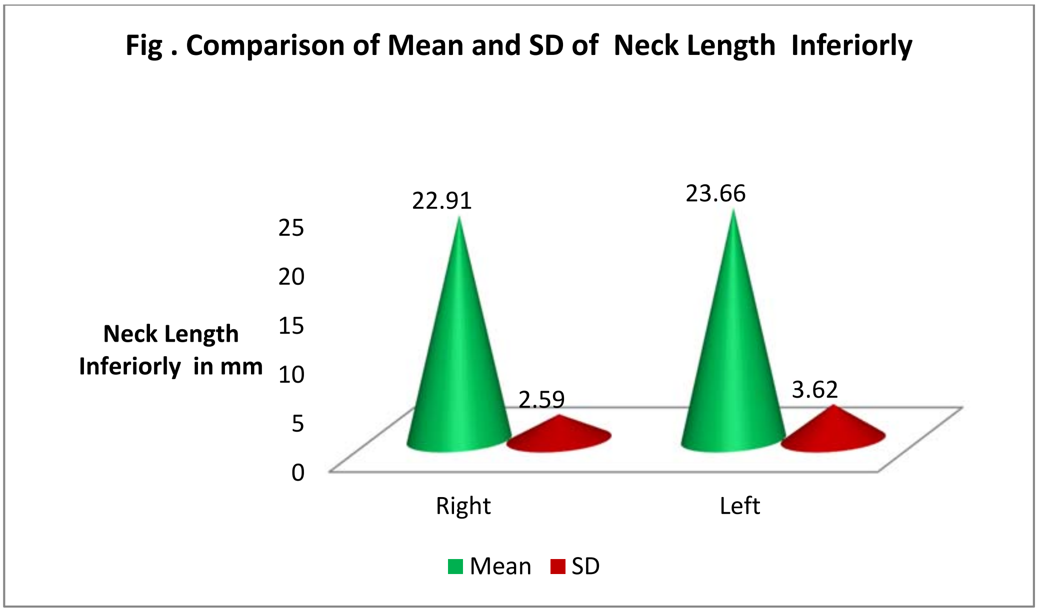


FIGURE -14: SHOWING MEASUREMENT OF FEMORAL NECK LENGTH INFEIORLY USING VERNIER CALIPERS

Neck Length Inferiorly is measured as the distance between bases of the head and midpoint of intertrochanteric crest. The two tailed student t-test is applied and the mean, standard deviation, Range, p-value, t-value are obtained. By applying the p and t value statistical significance was analysed.

Table – 8

Comparison of Mean and SD of Neck Length Inferiorly (NLI)

NLI in mm	Sample Size	Mean	SD	p-value	Inference
Right	50	29.11	2.68	>0.05	Not Significant
Left	50	30.21	3.40		

No significant side difference is noted in Neck Length Inferiorly on comparing both sides.

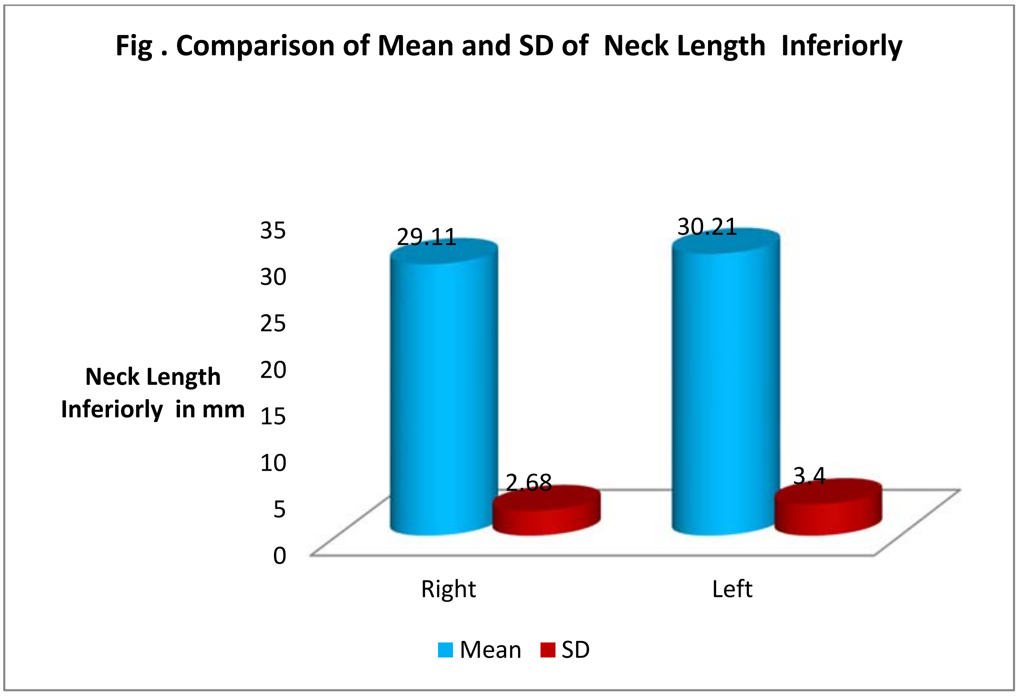


FIGURE: 15 SHOWING MEASUREMENT OF INTERTROCHANTERIC LENGTH OF FEMUR

Intertrochanteric length is measured as a distance between the areas above the lesser trochanter to the lateral most part of greater trochanter. The two tailed student t-test is applied and the mean, standard deviation, Range, p-value, t-value are obtained. By applying the p and t value statistical significance was analysed.

Table – 9

Comparison of Mean and SD of Intertrochanteric Length (IL)

IL in mm	Sample Size	Mean	SD	p-value	Inference
Right	50	56.97	5.99	>0.05	Not Significant
Left	50	58.1	6.04		

No significant side difference is noted in Intertrochanteric length on comparing both sides.

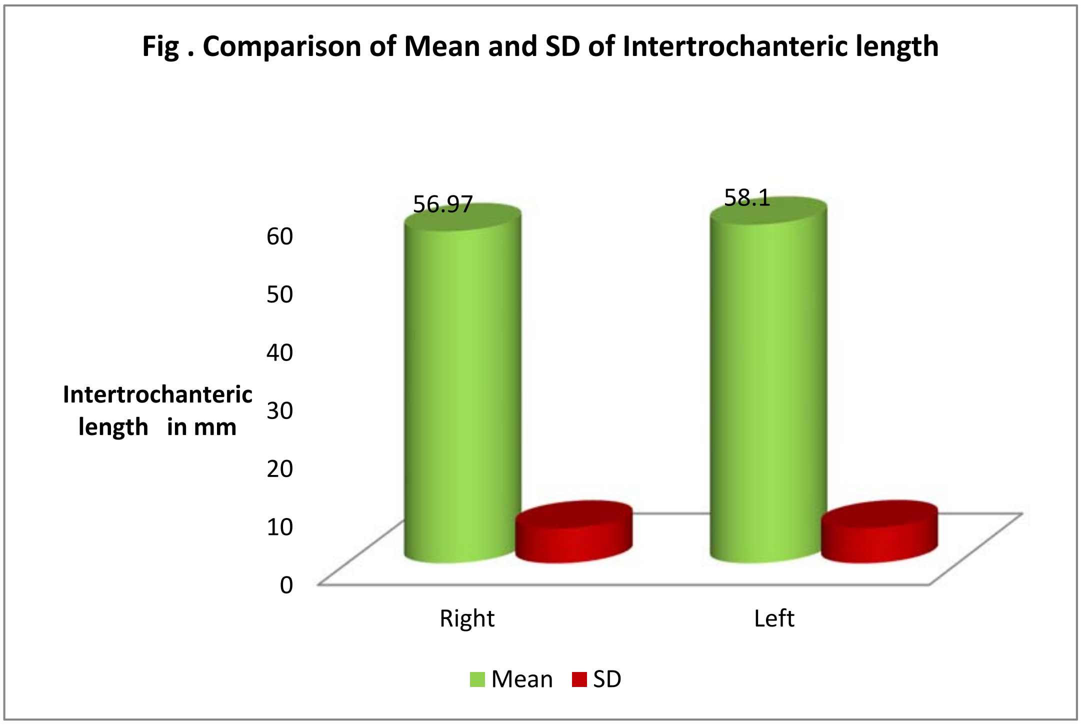


FIGURE 16: SHOWING MEASUREMENT OF NECK SHAFT ANGLE OF FEMUR

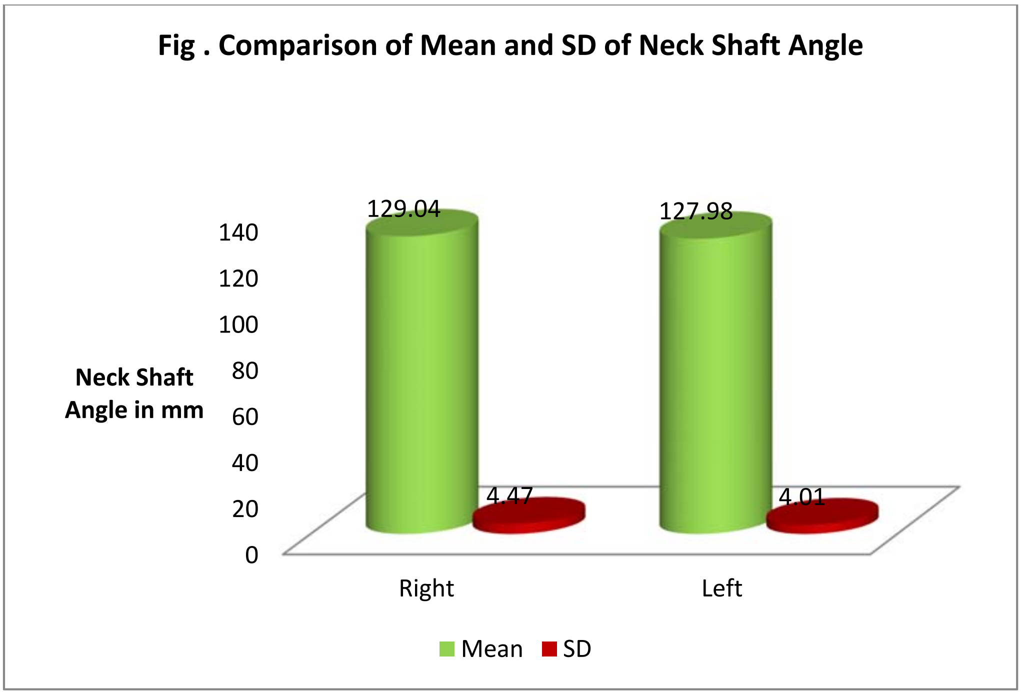
Neck Shaft Angle is measured as an obtuse angle between the long axis of the femoral neck to the long axis of the shaft of femur on the anterior surface of the femur. The two tailed student t-test is applied and the mean, standard deviation, Range, p-value, t-value are obtained. By applying the p and t value statistical significance was analysed.

Table – 10

Comparison of Mean and SD of Neck Shaft Angle (NSA)

NSA in mm	Sample Size	Mean	SD	p-value	Inference
Right	50	129.04	4.47	>0.05	Not Significant
Left	50	127.98	4.01		

No significant side difference is noted in Neck Shaft Angle on comparing both sides.



Quantitatively, there is no significant difference in all the Proximal Femoral Osteometric Parameters on right and left sides, except with respect to Neck Transverse Diameter which shows statistically significant difference on comparing both sides.

Table –11

Showing Parameters of Femora

Variable	**HVD**		**HTD**		**NVD**		**NTD**		**HL**	
	Right	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**
Sample	50	50	50	50	50	50	50	50	50	50
Mean	41.83	41.97	43.15	43.41	31.38	32.16	31.68	25.83	31.38	32.16
SD	3.75	4.11	3.55	3.77	3.47	3.49	3.43	2.95	3.47	3.49
Range	27.4-48.3	28.1-48.1	32.3-50.7	31.4-50.2	21.2-38.5	23.7-39.3	24.7-38.7	20-31.9	20-31.9	23.7-39.3
p-value	0.85		0.72		0.18		<0.01		0.25	
Inference	Not Significant		Not Significant		Not Significant		Highly Significant		Not Significant	

Variable	**HL(INF)**		**NL(SUP)**		**NL(INF)**		**ITL**		**NSA**	
	Right	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**	**Right**	**Left**
Sample	50	50	50	50	50	50	50	50	50	50
Mean	23.13	22.47	22.9	23.66	29.11	30.21	56.97	58.1	129.04	127.98
SD	2.98	2.79	2.59	3.62	2.68	3.4	5.99	6.04	4.47	4.01
Range	17.3-30.7	13.3-28.2	19.4-30.3	19.4-30.4	22.1-28.3	20.1-38.8	44.6-68	39.5-67.6	120-138	122-137
p-value	0.25		0.23		0.07		0.34		0.21	
Inference	Not Significant		Not Significant		Not Significant		Not Significant		Not Significant	

DISCUSSION

DISCUSSION

The present work "Study on Morphometry of Proximal Femur" is done on100 dry femora of which 50 belonged to right side and 50 belonged to left side. Osteometric measurements were obtained for all the bones.

Several studies said that racial differences have been shown to exist in the femoral head dimensions. The gross shape of the long bones is due to intrinsic factors while the specific features are determined by the adaptation of the bone to the functional environment. Therefore heredity is a major factor in the formation of shape of long bones due to its different functions in different races. Incongruous implant size or design may cause micro movements, laxation and intra-operative complications like intra-operative fractures and may negatively affect the outcome of the operation.

Most of the parameters of Indian femora are markedly different from other ethnic groups. For example, the average femoral head is lesser than the average Western value by as much as 5mm. likewise other anthropometric measurements can be seen to vary markedly from the Western values. So, implants designed for Western skeletons occupy much more space than Indian femoral head and neck.

Table – 12 Showing Comparison of Mean Head Vertical Diameter in Present Study with studies published in Literature

Author	Ethnic Group	Mean Value in mm
Singh	South East Nigerea	52.02
Nwoha	South West Nigerea	50.35
Igbigbi	Malawions	48.3
Akhtari	Bangladesh	45.65
Rubin PJ	France	43.4
Baharuddin	Malaysia	43.4
Taner Z	Turkey	43.67
Present Study		41.9

The Value of mean head vertical diameter in the present study is closely comparable with study done by TanerZ

Fig. Showing Comparison of Mean Head Vertical Diameter in Present Study with studies published in Literature

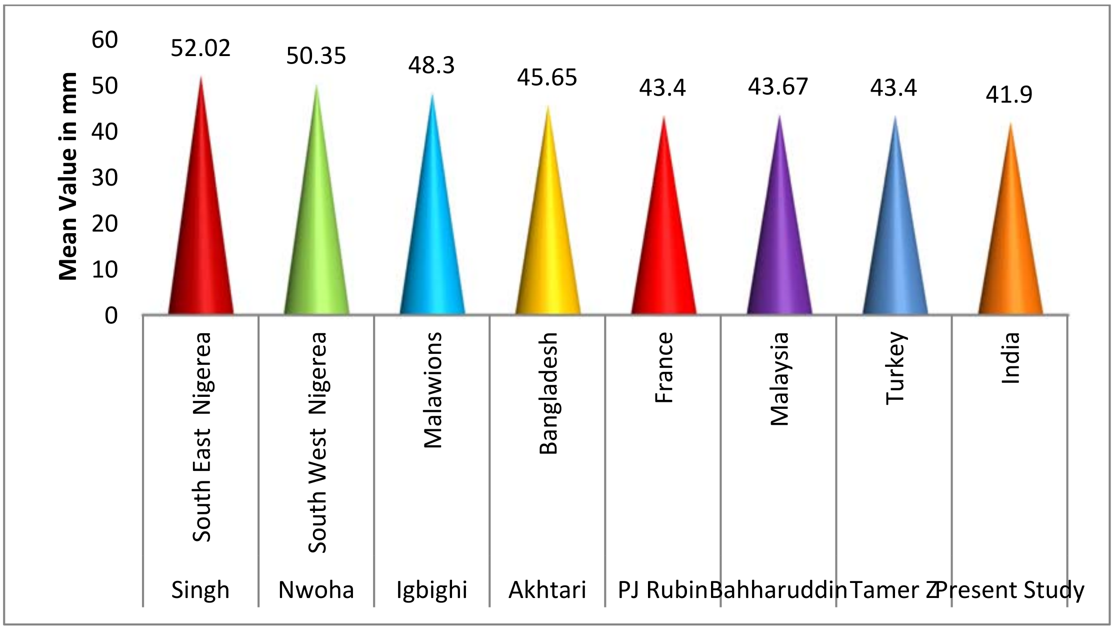


Table – 13 Showing Comparison of Mean Head Transverse Diameter in Present Study with studies published in Literature

Author	Ethnic Group	Mean Value in mm
Singh	South East Nigerea	54.16
Nwoha	South West Nigerea	50.75
Igbighi	Malawions	50.51
Akhtari	Bangladesh	42.2
Present Study	India	43.28

The Value of mean head transverse diameter in the present study is closely comparable with study done by Akhtari

Fig. Showing Comparison of Mean Head Transverse Diameter in Present Study with studies published in Literature

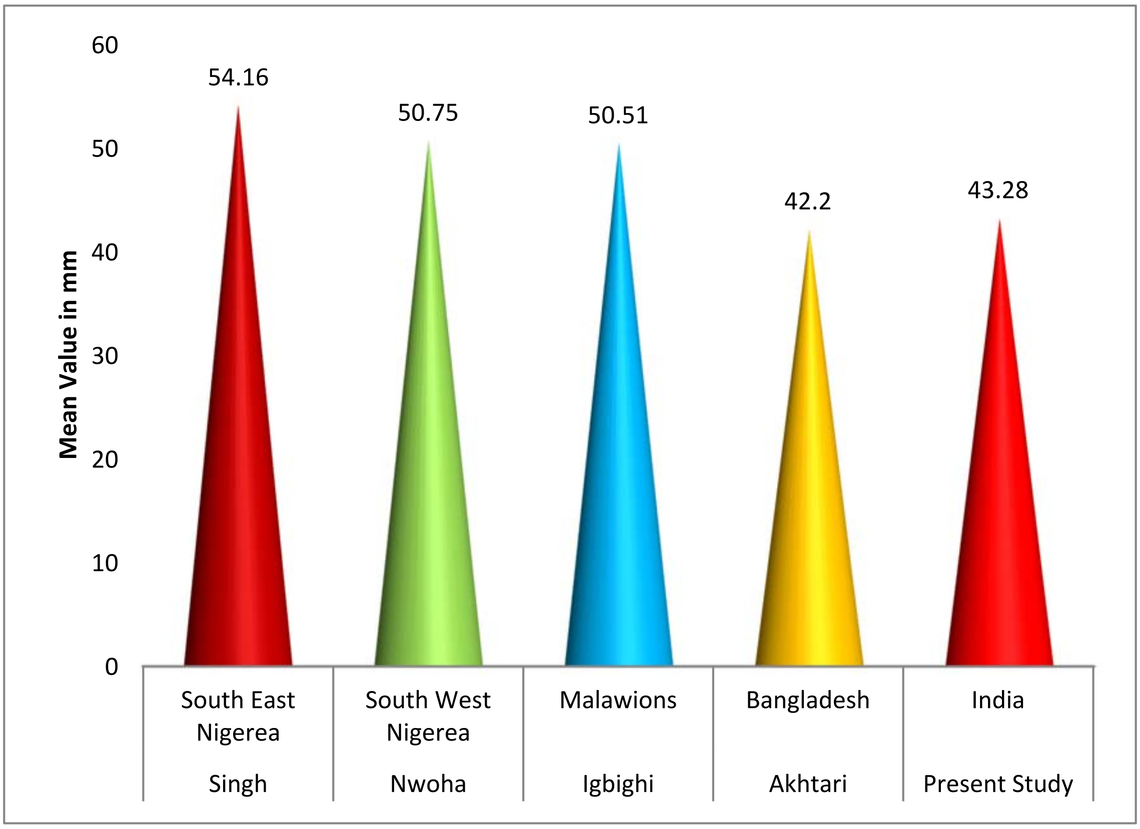


Table – 14 Showing Comparison of Mean Neck Width in Present Study with studies published in Literature

Author	Ethnic Group	Mean Value in mm
Tamer Z	Turkey	28.51
Chiu CK.	Malaysia	34
Caetano EB.	Brazil	28.60
Present Study	India	32.19

The Value of mean Neck Width in the present study is closely comparable with study done by Ckchiu

Fig. Showing Comparison of Mean Neck Width in Present Study with studies published in Literature

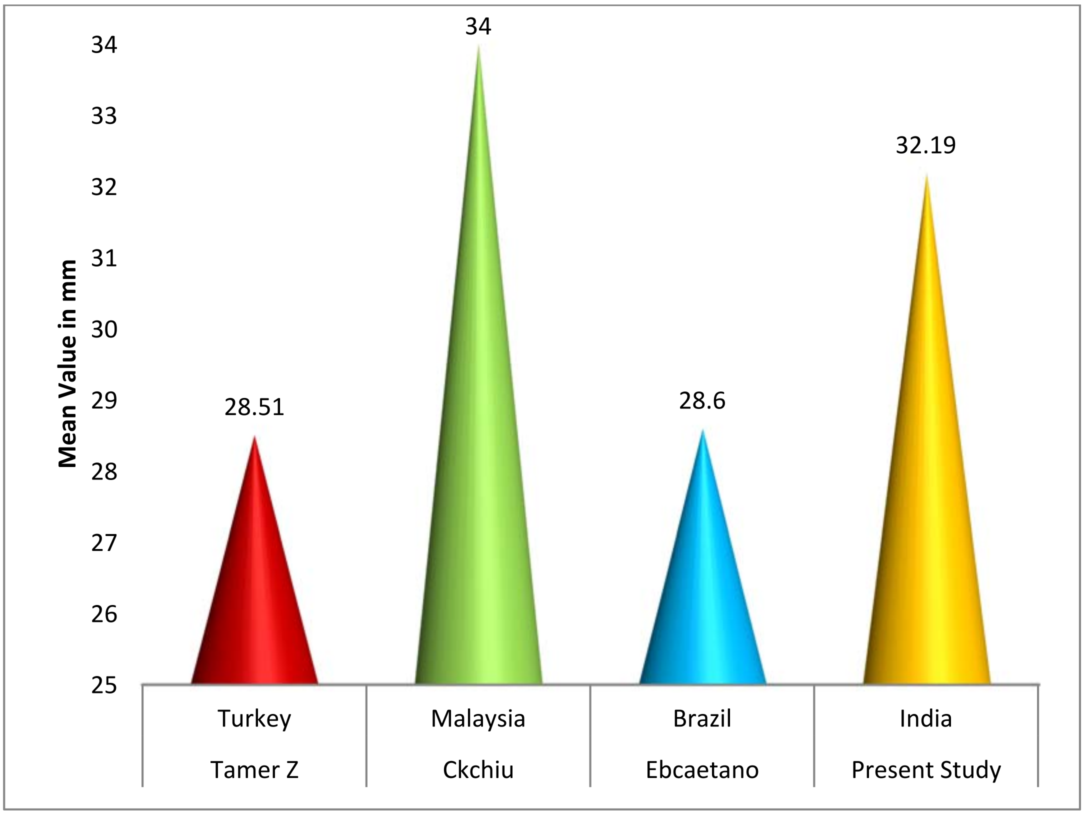


Table – 15 Showing the Comparison of Mean Neck Width among Indian Authors

Author	Mean Value in mm
Siwach RC. Et al.	31.8
Misheard AK. et al.	30.52
D.Ravichandran	30.99
Present Study	32.19

The Value of Mean Neck Width in the present study is closely comparable with study done by Siwach R

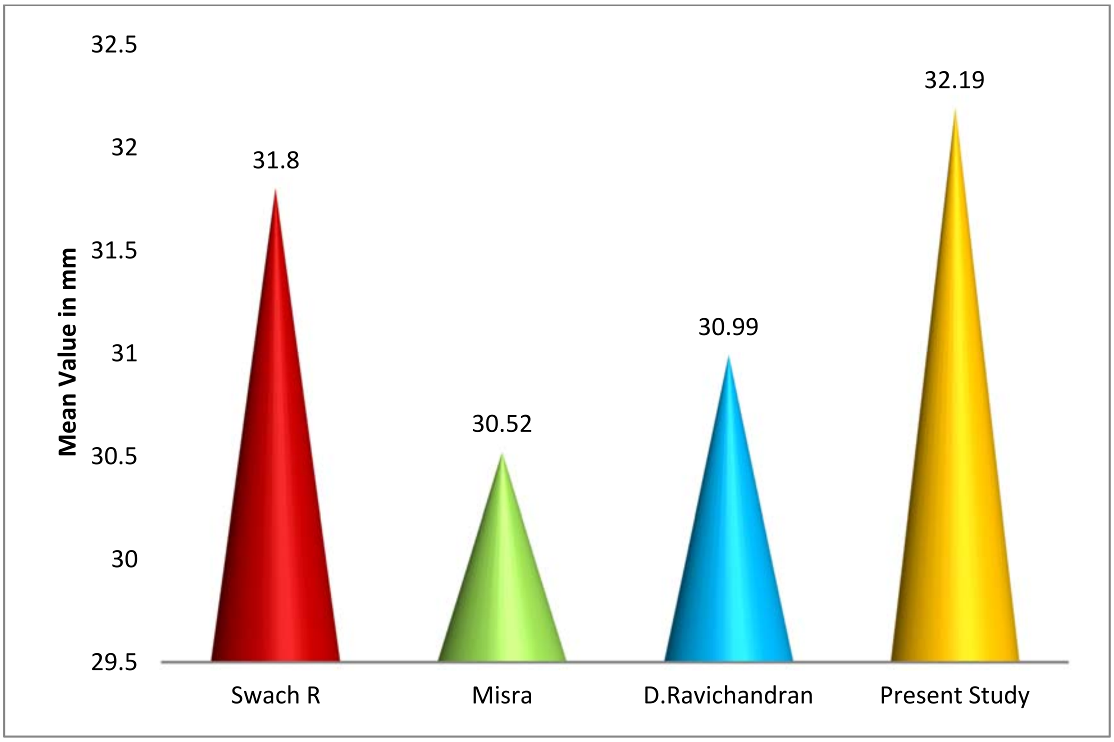


Table – 16 Showing the Comparison of Mean Neck Transverse Diameter among Indian Authors

Author	Mean Value in mm
Murilimanju BV	23.9
Present Study	25.03

The mean Neck Transverse Diameter in the present study is closely correcting with values obtained by the study of B.V.Murilimanju

Fig. Showing the Comparison of Mean Neck Transverse Diameter among India Authors

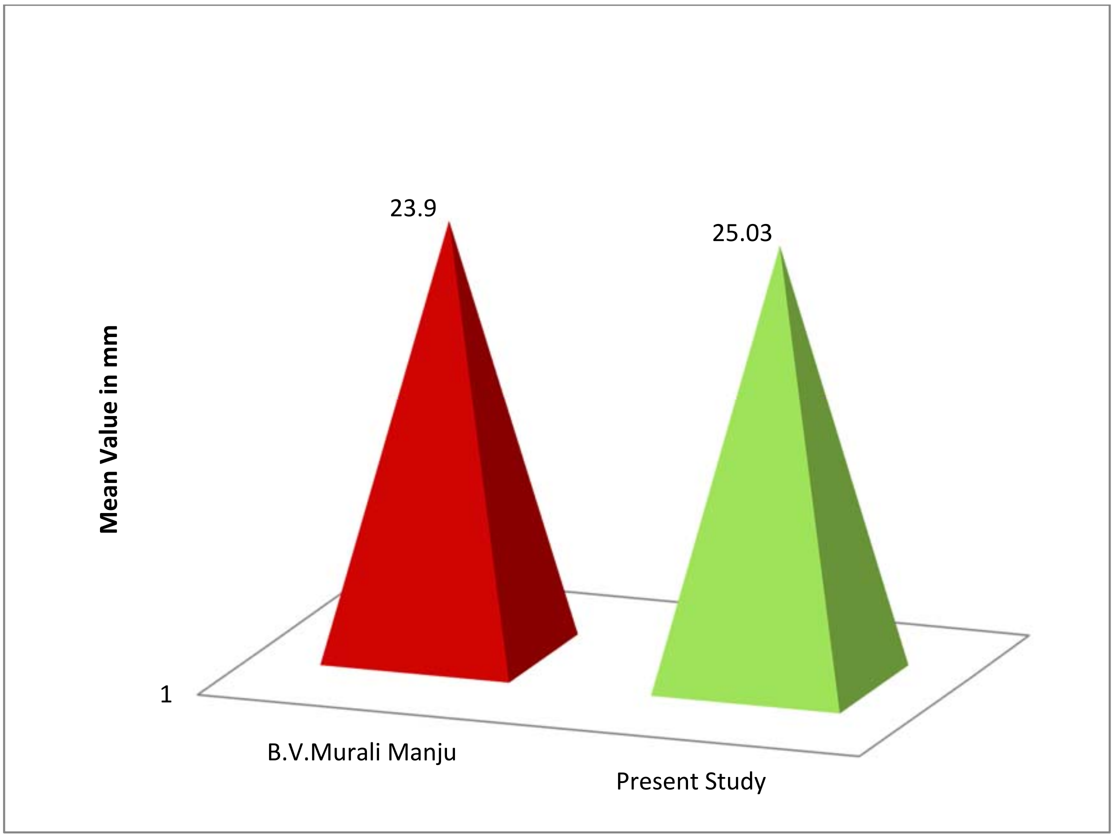


Table – 17 Showing the Comparison of Mean Neck Length among Indian Authors

Author	Mean Value in mm
Osario H.etal.	35.9
Parson FG	31.0
Mishra AK. et al.	46.22
Issac B et al.	28.35
Present Study	28.49

The mean Neck Length in the present study is closely correcting with radius obtained by IssacBetal.

Fig. Showing the Comparison of Mean Neck Length among Indian Authors

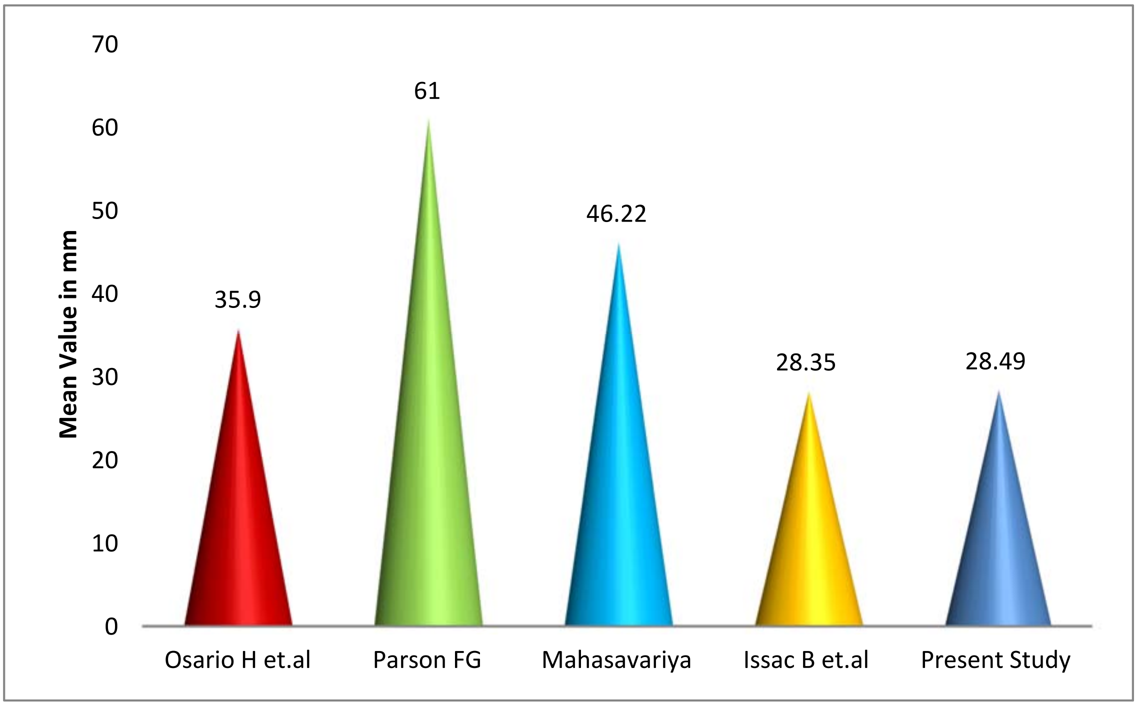


Table – 18 Showing the Comparison of Femoral Head Length Superiorly

Author	Mean Head Length Superiorly
B.V.Murilimanju	30.8
Present Study	31.77

Fig. Showing the Comparison of Femoral Head Length Superiorly

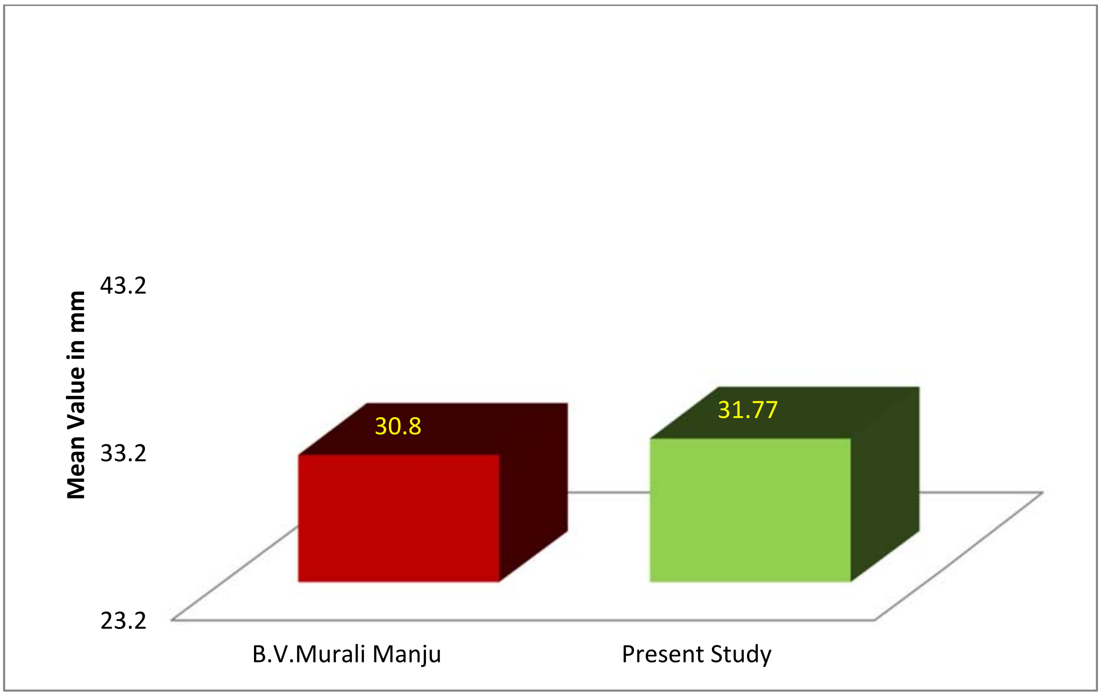


Table – 19 Showing the Comparison of Mean Head Length Inferiorly

Author	Mean Head Length Inferiorly
B.V.Murilimanju	21.2
Present Study	22.8

Fig. Showing the Comparisonof Femoral Head Length Superiorly

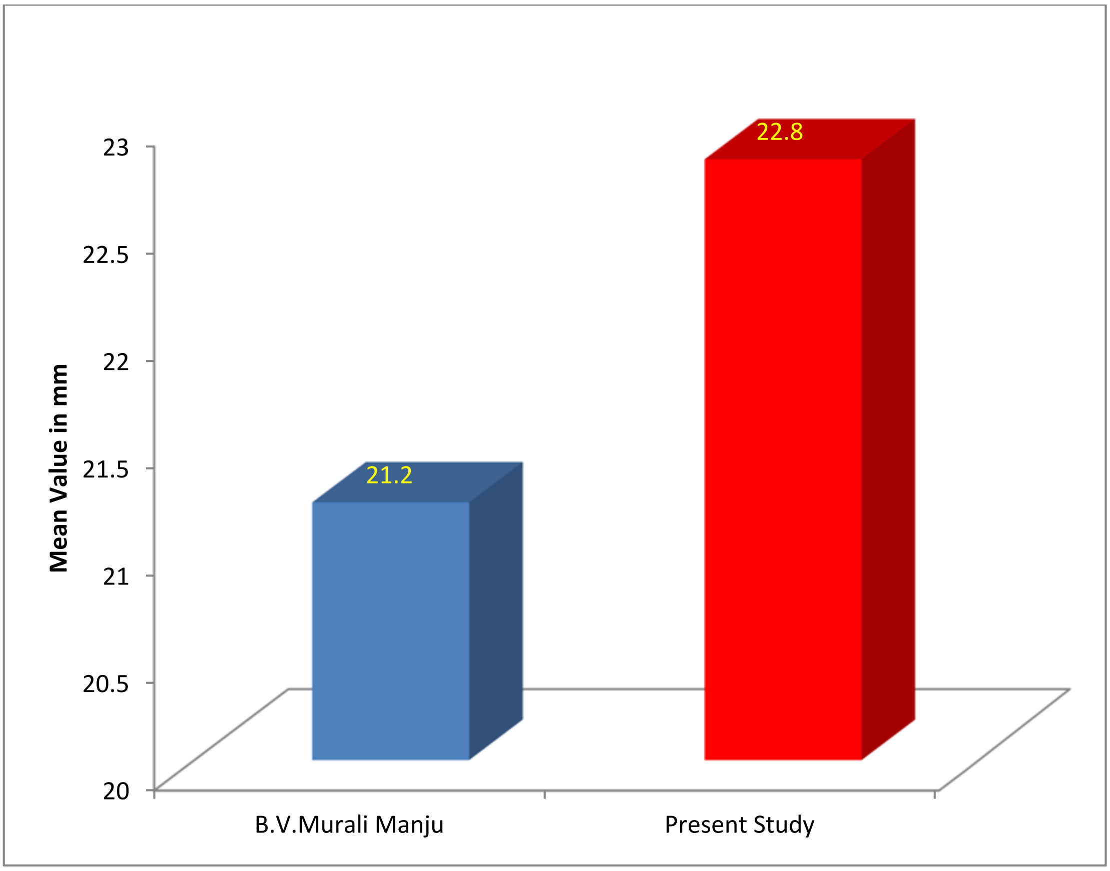


Table – 20 Showing Comparison of Neck Shaft Angle in Various

Author	Ethnic Group	Mean Value in degrees
HoracioOsario	Chile	124.17°
Rubin et al.	Swiss	122.9°
Husmann et al.	France	129.2°
Isacc B et al.	Thai	126.9°
Toogood Paul	White & American	126.7°
Noble et.al	Caucosdids	125.4°
Present Study	India	128.4°

Fig. Showing Comparison of Neck Shaft Angle in Various

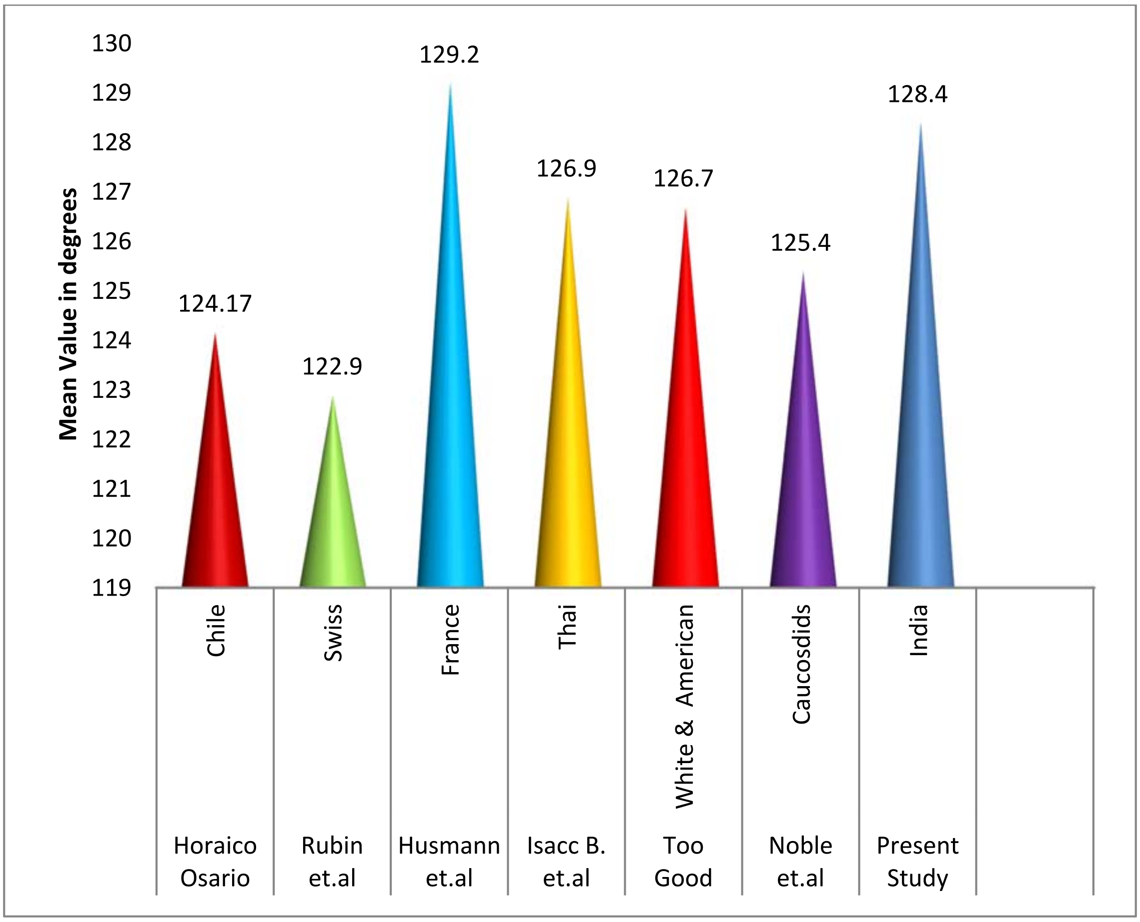


Table No. 21 showing Comparison of Neck Shaft Angle with Commonly used Implants

IMPLANT	VALUE
Dynamic hip screw (DHS)	125-155°
Commonly used DHS	135°
Condylar Blade plate	95°-130°
Commonly used	95° or 110°
Present study	128.4°

Table No. 22 Showing Comparison of Neck width between Dimensions of Indian Femora and Dimensions of Implants (Ao Screws)

uthor	Neck Width (mean in mm)	Dimension of the Implant
Ravichandran	30.99	6.5mm (three screws are commonly used- 6.5 x 3 =19.5mm)
Present Study	25.03	

SUMMARY AND CONCLUSIONS

The morphology of proximal femur has been qualitatively and quantitatively described by considering a variety of features and parameters. On qualitative study of the proximal femur,

- Femoral Head Shape appears normal (more than half a sphere)
- Fovea centralis is found to be normal in position in all the specimens (above the centre of the head) and shape is rounded in all cases except 7specimens, where it is found to be oval in shape.
- Femoral Neck with numerous vascular foramina on its anterior surface is observed.
- Greater Trochanter is quadrilateral in shape in all the specimens.
- Lesser Trochanter is conical in shape except in two specimens in which it is rounded.
- Intertrochanteric Line is observed as the prominent ridge over the anterior aspect at the junction of femoral neck with the shaft in all the specimens.
- Intertrochanteric Crest is observed as smooth ridge over the posterior surface at the junction of the femoral neck with the shaft.

- Gluteal Tuberosity is observed over the posterior aspect of the femur in all the specimens except in specimens where it is depressed and flat.

Quantitative Measurements were carried out and the following results were obtained.

- The Head Vertical Diameter (HVD) on right side is observed to be 41.83 mm and on the left is 41.97 mm. No significant side difference is observed on comparing both sides.
- Head Transverse Diameter (HTD) on right side is found to be 43.15 mm and on the left side it is 43.41 mm. No significant side difference is noted.
- The Neck Vertical Diameter on right side is 31.68 mm and on the left side is 32.66 mm. No significant side difference is seen.
- The Neck Transverse Diameter on right side is 24.24 mm and on the left side it is 25.83 mm, showing a statistically significant difference.
- The Head Length of the femur superiorly on right side is 31.8 mm and on the left side is 32.16 mm. No significant side difference is seen.

- The Head Length of the femur inferiorly on right side is 23.13 mm and on the left side is 22.47 mm. No significant side difference is seen.
- The Neck Length of the femur superiorly on right side is 22.91 mm and on the left side is 23.66 mm. No significant side difference is seen.
- The Neck Length of the femur inferiorly on right side is 29.11 mm and on the left side is 30.21 mm. No significant side difference is seen.
- The Intertrochanteric length on right side is 56.97 mm and on the left side is 58.1 mm, showing no variation on comparing both sides.
- The Mean Neck Shaft Angle of the right sided femora is 129.04 degrees and on the left sided femora is 127.98 degrees.

CONCLUSION

Qualitative parameters were measured in all the Femora and statistical analysis of each parameter by side wise comparison was made. The values of the parameters obtained were compared with those reported in the literature. And the values were compared with dimensions of commonly used implants in the field of Orthopaedics.

The values observed for all the parameters were greater in the Western world than in the present study and it was concluded that Western people were taller and heavier than the average Indians, thus showing regional variation. This study will encourage the biomechanical engineers to bring a revolution in the designing and manufacturing of implants with a correct morphometric data to suit our Indian Population and for an improvised surgical outcome with prevention of complications.

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ANNEXURE

MASTER CHART

S.NO	HVDR	HVDL	HTDR	HTDL	NVDR	NVDL	NTDR	NTDL	SHLR	SHLL	IHLR	IHLL	SNLR	SNLL	INLR	INLL	ITLR	ITLL	NSAR	NSAL
1	44.2	48.1	50.7	43.4	36.8	35.1	31.8	30.6	38.5	31.1	24.2	24.1	22.7	21.9	29.4	29.6	66.9	67.6	124	125
2	41.7	43.6	46.8	46.5	35.2	34.1	24.2	27.4	34.6	36.9	20.7	21.5	20.2	20.5	27.6	28.4	58.6	51.7	125	127
3	43.1	40	45.3	47.2	33.1	32.4	27.8	26.4	33.6	33.9	20	21.7	20.6	19.1	27.8	28.4	51.2	49.3	125	131
4	41.8	42.9	43.1	46.9	31.7	32.2	23.5	25.1	34.2	32.8	24.5	22.3	21.6	20.3	28.5	28.2	49.8	67.1	121	125
5	42.5	28.1	47.6	42.4	28.7	30.5	24.3	24.3	32.2	32.7	27	23.5	21.9	20.4	29.8	28.7	68	57.2	131	124
6	41.4	42.2	42.6	31.4	36.7	32.4	27.1	29.3	30.7	30.9	28.8	26.6	21	20.7	30.1	31.8	57.5	53.4	136	129
7	40.2	43.1	42.6	45.2	33.4	32.3	23.2	22.4	29.1	33.2	27.2	22.7	20.2	21.6	27.2	28.8	59.8	60.7	126	125
8	47.3	36.6	42.6	44.8	33.6	32.1	24.6	27.3	33.7	28.9	23.1	24.6	20.2	19.7	27.2	28.6	63.6	58.2	133	124
9	44.8	35.1	47.7	38.7	36.5	37.8	27.6	27.1	32.4	32	25.8	23.9	21.3	21.3	29.1	30.3	53.3	55.9	127	127
10	41	42.1	42.1	40.5	31.3	32.1	22.9	24.1	31.8	34.4	21.1	25.9	21.3	23.4	30.8	30.9	50.4	57	135	128
11	41.2	40	42	49.7	30.8	32.1	23.6	27.9	34.9	34.6	21.7	20.3	23.7	23.9	28	33.6	62.2	26.2	125	126
12	43	43.3	43.5	45.3	26.3	30.2	24.6	23.8	30.8	32.2	26.5	19.4	23.3	25	31.1	30.8	61.9	39.5	133	127
13	36.7	37.8	40.2	38.1	32.7	30.2	23.6	23.1	28.6	39.2	24.2	22.6	20.5	25.7	30	33.1	47.5	56.8	135	125
14	37.2	36.3	40.3	43.6	27.3	30.1	20.3	23.2	27.1	32.6	20.1	20.7	21.8	25.2	28.2	33	61.4	64	127	129
15	39	45.8	38.1	45.9	24.1	46.2	21.7	31.9	26.9	33.1	17.3	25.2	22.9	27.4	31.1	34.4	67.9	46.8	127	125
16	42.6	44.5	44.7	41.3	36.2	30.5	26.9	23.8	33.9	36.2	18.9	18.4	23.1	27.4	30	30.9	60.6	56.5	133	127
17	41.6	47.2	42.1	41	34.5	33	26.5	27.4	23.8	26.9	28.6	27.5	20.3	24.3	30.4	28.6	51.6	62.4	132	126
18	38.6	41.4	40.2	43.7	30.6	25	21.5	21.2	31.6	30.6	20.5	13.3	20.8	28.3	28.2	26.4	52.1	62.6	129	132
19	38	46.3	40.2	50.2	28.3	24.7	23.6	20.1	30.4	27.8	22.9	18.6	23.8	24.8	27.1	30.7	49.3	46.3	132	129
20	46.5	46.1	47.2	45.4	24	37.8	25.1	27.4	30.8	30.8	25.1	27	30.3	21.2	30	27.6	58.9	52.1	136	132
21	27.4	39.8	32.3	46.2	25	38.4	23	28.6	21.2	36.6	20.7	28.2	20.1	22.6	30.4	25.3	47.4	63.2	126	123
22	45.7	30.2	47.8	46.5	36.9	29.6	25.3	20	33	35.4	20.1	18.7	25.7	11.1	31.3	22.8	55.8	62.7	132	135
23	45.4	44.8	35.1	43.8	27.8	34.7	20.8	30.2	25.8	25.7	19.5	22.1	22.4	24.5	27.7	30.9	62.3	56.9	124	122
24	45.4	45.5	46.5	47.6	31.2	34	23.6	24.2	36.4	30.1	24.6	21.2	21.3	23.7	32.5	30.6	56.7	59	128	131

25	48	35.9	48.5	41.2	28	33.6	26.3	27.5	38.1	30.8	30.7	18	24.3	27.1	30.1	34.8	58.3	8	130	129
26	35.4	41.6	43.8	43.5	36.1	-40.7	25	26.4	29.8	28.8	25.3	25.7	23.6	23.1	27.2	38.3	53.1	51.5	132	132
27	44.1	47.6	44.8	47.6	30.4	32.1	25.4	24.4	33.7	36.7	23.6	21.2	22.3	24.1	33.6	29.6	59.4	55.9	127	133
28	44.5	43.3	44.6	44.4	33.6	28.4	22.8	21.9	34.6	32.8	23.3	21.8	27.3	24	31.1	29	62.5	62.5	129	131
29	44.4	40.7	40.9	46	30.2	27.9	28	22.7	33.4	31.1	25.1	19.8	25.3	24.3	28.5	30.1	58	60.4	124	131
30	40.3	41.1	42.3	45	31	35.3	21.1	25.9	31.4	26.8	21.5	24	20.17	21	26.8	31.3	58.7	56.8	125	129
31	40.9	41.3	41.8	45	28.4	29.7	28.1	25.1	31.5	32.4	24.4	20.3	27.2	26.4	29.6	32.8	64.2	59.2	125	123
32	39.3	43.6	42	42.4	30.5	35.9	22.5	29.2	29.8	31	21.1	25.4	19.4	28.7	24.5	29.7	60.6	54.2	127	122
33	41.9	40.7	48.8	50.2	31.9	32.8	25.1	25.2	32.6	33.9	22.9	22.1	23.7	30.8	32	30.4	58.6	60.5	124	124
34	48.3	41	41.4	42.7	31	35	25	25.2	33.8	34.9	25.9	22.3	25.3	27.6	29.4	35.5	57.5	63.8	126	125
35	42.3	41.2	43.5	44.6	30.7	36.4	22.8	24.6	26.5	37.6	19.5	25.7	21.1	25.4	25.1	31.4	65.8	56	124	124
36	42.4	43.7	43.2	37.7	35.7	33.7	20.5	25.2	31.7	39.3	20.9	24.7	26.8	21	31.1	30.8	58.8	57.1	127	127
37	41.3	47.6	42.9	37.7	33.9	28.4	23.9	25.1	31.1	36.1	21.1	21.9	24.7	15.2	33.1	27.7	50.5	63.3	135	130
38	37.1	41	38.3	44.3	25.4	25	22.8	29.2	29.8	32.6	17.9	17.9	20.4	27.5	31	31.5	50.1	56	132	137
39	42.6	43.7	46.1	43.8	32.2	32.1	20	28	25.8	23.7	25.2	23.3	27.3	27.2	26.4	35.8	65.1	57.1	126	123
40	37.9	47.6	44.9	36.2	31.4	37.8	24	23.5	32.7	34.6	24.3	23.8	28	19.9	30.8	24.6	47.6	64.4	135	128
41	48.3	46.1	44.4	43.8	29.8	27.2	22	30.6	34.3	37.2	24	22	28.2	27.2	34	35.5	51.3	60.3	126	132
42	40.7	41.1	38.9	42.7	27.7	35.3	25.4	25.7	27.3	31.9	20	23.9	25.2	28.5	29.9	31.1	55	67	129	132
43	40.9	44.6	41.3	44.3	32.5	36.3	21.2	22.6	28.8	31.6	22	25.5	22.1	19.2	27.3	23.5	60.1	61.5	137	127
44	45.7	39.2	43.7	48.1	30.6	35.6	24.7	27.3	34.5	34	25.8	23.6	20.7	26.7	27.4	30.5	6505	48.4	138	126
45	44.7	43.1	41.3	45.5	35.3	28.2	25.3	28.6	32.5	32.4	22.1	19.6	22.2	21.3	27.6	34.3	51.9	66.1	136	124
46	37.9	41	48.7	36.9	28.6	32	24	20.1	30.1	26.9	25.7	21.1	22.8	24.3	25.9	30.6	47.6	65.3	130	137
47	45.7	45.2	38.3	35.4	38.7	33.8	27.7	22.8	36.3	26.2	20.8	23.7	20.5	28.1	29.8	30.4	62.1	65.3	127	127
48	41.1	42.5	44.8	44	31.2	30	20.3	20.1	30.4	37.2	24.3	22.2	21.3	20.1	24.3	32.4	60.1	50.5	130	127
49	39.9	38.9	44.7	42.7	34.9	28.3	27.1	26.6	31.5	35.4	25	24.2	21.1	23.2	26.8	29.6	56.8	48.2	127	126
50	41.1	43.4	41.3	45.3	30.3	28	27.2	25.1	31.1	35.2	20.1	22.6	21.2	22.7	27.6	30.5	58	58.1	128	127

PROFORMA

The following data are noted from the upper end of femora under study

The Qualitative features include:

1. Femoral Head with Fovea Centralis – Shape and Location
2. Femoral Neck – Along with Vascular Foramina
3. Greater Trochanter – Shape and Location
4. Lesser Trochanter – Shape and Location
5. Intertrochanteric Line – Extent and Location
6. Intertrochanteric Crest – Extent and Location
7. Gluteal Tuberosity – any Ridges or Depressions

The Quantitative Parameters Includes

8. Head Vertical Diameter
9. Head Transverse Diameter
10. Neck Vertical Diameter
11. Neck Transverse Diameter
12. Head Length Superiorly
13. Head Length Inferiorly
14. Neck Length Superiorly
15. Neck Length Inferiorly
16. Intertrochanteric Length
17. Neck Shaft Angle

MADURAI MEDICAL COLLEGE

MADURAI, TAMILNADU, INDIA -625 020

(Affiliated to The Tamilnadu Dr.MGR Medical University, Chennai, Tamil Nadu)

ETHICS COMMITTEE CERTIFICATE

Name of the Candidate	:	Dr.K.Geethanjali
Course	:	PG in MD., Anatomy
Period of Study	:	2016-2019
College	:	MADURAI MEDICAL COLLEGE
Research Topic	:	Study on morphometry of proximal femur
Ethical Committee as on	:	16.05.2018

The Ethics Committee, Madurai Medical College has decided to inform that your Research proposal is accepted.

Member Secretary   Chairman   Dean / Convenor

Prof Dr V Nagaraajan
M.D., MNAMS, D.M., Dsc.,(Neuro), Dsc (Hon)
CHAIRMAN
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